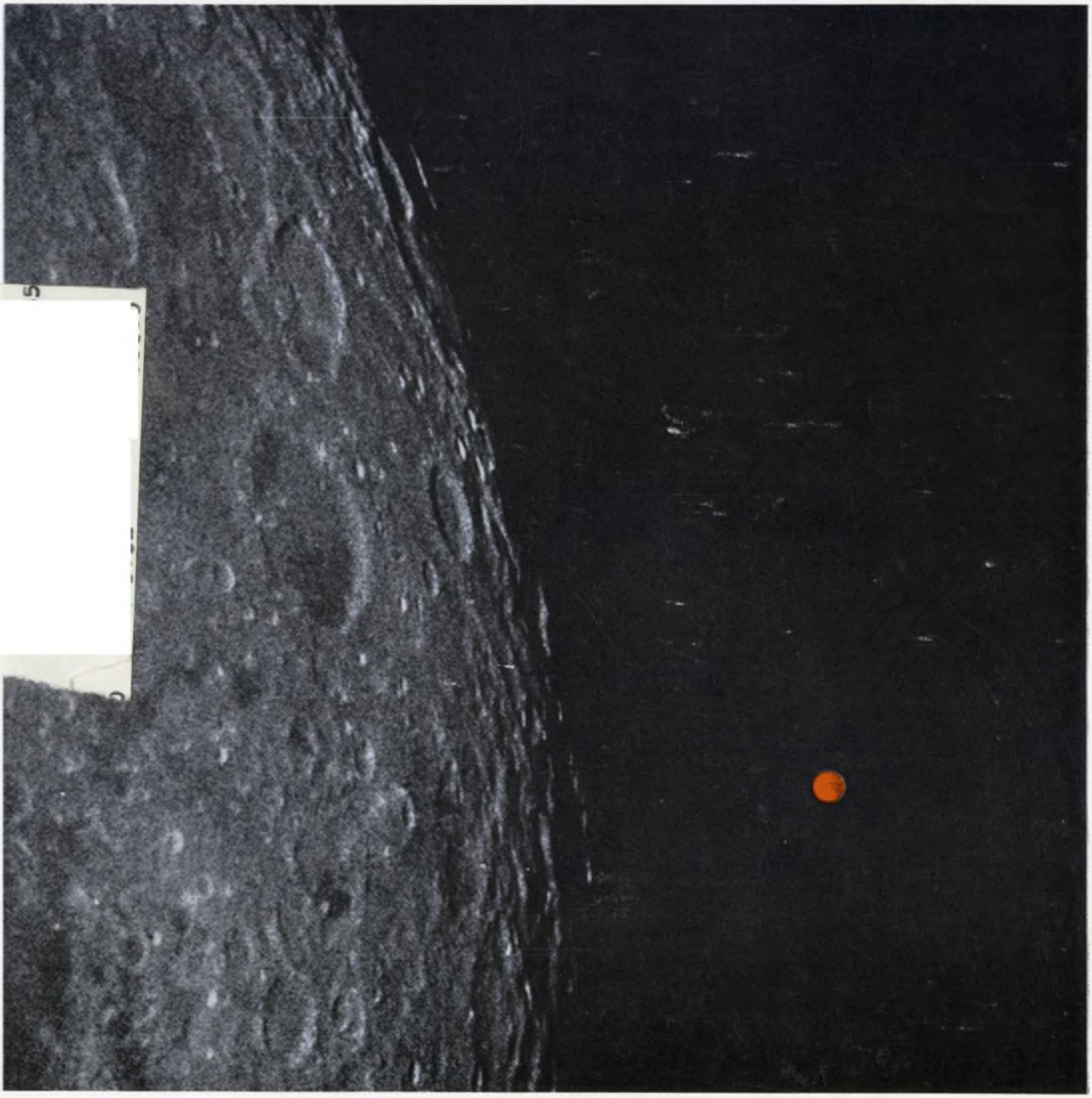
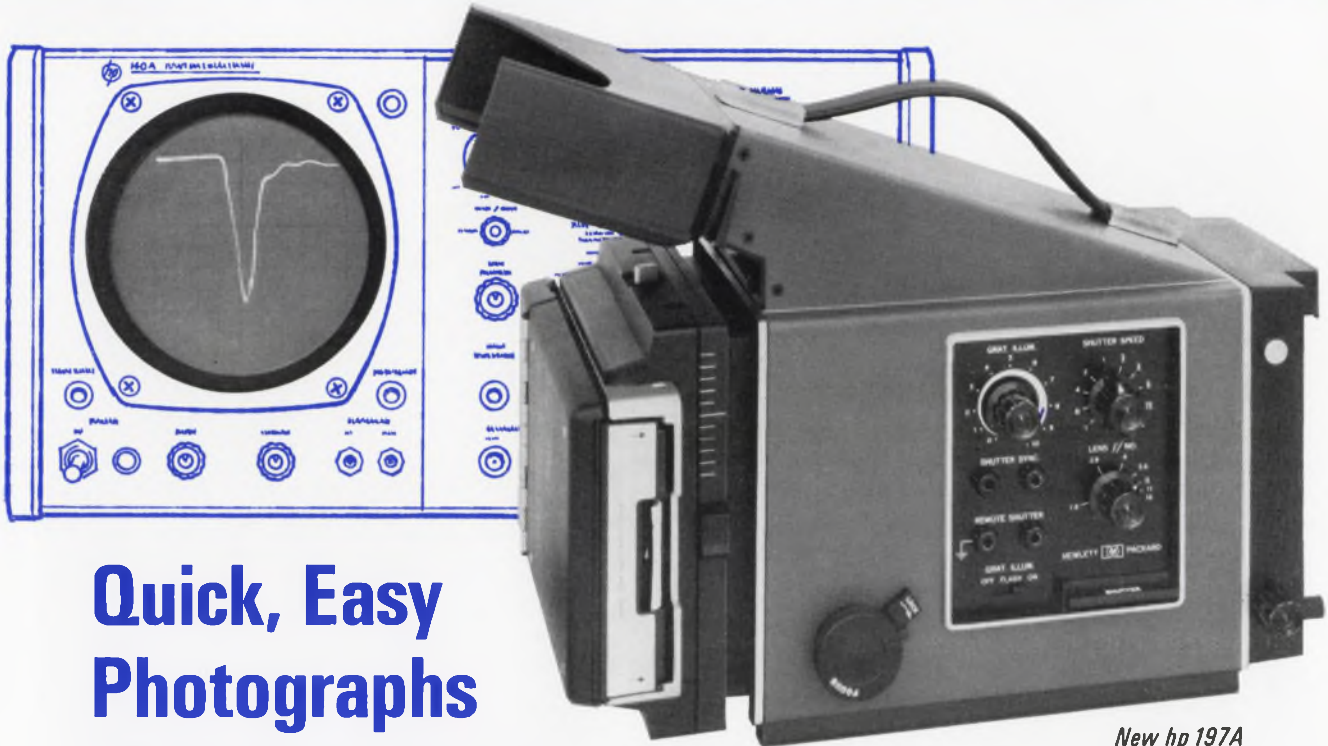
VOL. 14, NO.

Electronic Design 24

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY
OCTOBER 25, 1966

The robots we rocket to Mars will search for forms of life that may not resemble anything on this planet. Investigations beyond the moon require machines that can peer about, decide what to chase, make tests and send their findings back to the earth. Such expendable scientists will rely on new electronics. See page 17.





Quick, Easy Photographs of Scope Traces

New hp 197A Scope Camera

- **External color-coded controls offer easy camera operation**
- **Electronically controlled shutter provides remote operation, long life**
- **Interchangeable camera backs, adjustable reduction ratio offer camera versatility, to match your photo needs**

Fast camera operation is yours with easy to read, easy to adjust controls on an external panel. Color coding of controls indicates best settings for normal applications; lets you get the right picture the first time. Even photos of single-shot events are easy to take. The ultraviolet light for illuminating the hp internal graticule can be automatically flashed to provide graticule lighting simultaneously with the trace, eliminating the need for double exposures.

The solid-state electronic shutter circuitry assures accurate shutter speeds and permits remote triggering for such applications as operating several cameras simultaneously or in synchronization with other equipment. Photography is reliable and repeatable. A sync output is available for triggering external equipment.

Interchangeability of the standard Polaroid® camera back with an optional 4"x5" Graflok® back provides increased versatility. A continuously adjustable reduction ratio lets you utilize the entire film area. The camera can be focused quickly with an external control and a split-image focusing plate which is provided. For multiple exposures the backs are rotatable and can be moved vertically through eleven detented positions. The entire camera swings away from its mounting when not in use.

Brief additional specifications here indicate the usefulness of this, today's most advanced scope camera. Further information is available with a call to your Hewlett-Packard field engineer or by writing Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD
An extra measure of quality

SPECIFICATIONS

Reduction ratio: continuously adjustable, 1:1 to 1:0.7, simple screwdriver adjustment

Lens: Wollensak 75 mm, f/1.9, standard; aperture ranges f/1.9-f/16. Oscillo-Raptar 88 mm f/1.4 optional at extra cost

Shutter: electronically operated and timed: available speeds: Time, Bulb, 4, 2, 1, ½, ¼, ⅛, 1/15, 1/30 sec.; input jack for remote operation; sync contact closure for triggering external equipment

Viewing: direct-viewing hood with flexible face mask; hood is removable and can be replaced with a panel to facilitate stacking on 7" rack-mounted scopes

Camera backs: Polaroid® Land Pack Film Back, interchangeable with optional 4 x 5 Graflok® back; backs can be rotated in 90° increments

Multiple exposure: back moves vertically through 11 detented positions

Mounting: direct on all Hewlett-Packard scopes, adapters available for other models; camera swings away to left

Price: 197A Oscilloscope Camera, $475; Option 01 (without UV light), $425

Prices f.o.b. factory.

®—"Polaroid" by Polaroid Corporation; "Graflok" by Graflex, Inc. 1185

With this NEW instrument you can test practically any capacitor

. . . especially electrolytics to MIL or EIA Standards

THIS CAPACITANCE BRIDGE

. . . has a C range of 10^{12}, from 1 pF to 1.1F . . . with an accuracy of ±1% to 0.11F and ±2% from 0.11F to 1.1F.

. . . has a D range from 0 to 10 with an accuracy of approximately ±2%.

. . . is completely self-contained; just plug it into a power line and start making measurements. The 120-Hz generator, tuned detector, adjustable dc polarizing voltage and bridge circuits are all contained in a GR-patented, Flip-Tilt cabinet/carrying case.

. . . has an internal, metered dc polarizing voltage that is adjustable from 0 to 600 volts.

. . . provides for 2-, 3-, 4- or 5-terminal connections; effects of residual impedances are practically eliminated.

. . . measures leakage current down to 0.5 μA.

. . . can be used up to 1000 Hz with an external generator.

. . . has panel safety lights to indicate when bias voltage is being applied and when the charge on the unknown capacitor exceeds one volt.

. . . has ORTHONULL® balance finder, which eliminates sliding balance when high-D capacitors are measured.

. . . has a phase-reversible 120-Hz generator to reduce the effects of stray voltage; amplitude is selectable and limited to 0.2V, 0.5V, or 2V.

. . . meets or exceeds requirements of standards including MIL-C-39003 (Solid Tantalum), MIL-C-39018 (Aluminum Oxide), MIL-C-62 B (Polarized Aluminum), MIL-C-26655 B (Solid Tantalum), MIL-C-3965 C (Tantalum Foil and Sintered Slug), (EIA) RS 154 B (Dry Aluminum), (EIA) RS 205 (Electrolytic), (EIA) RE 228 (Tantalum).

. . . Price is $1195, Type 1617-A Capacitance Bridge.

Models are available for portable use, rack mounting, 115- or 230-V input, 50- or 60-Hz.

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GENERAL RADIO

WEST CONCORD, MASSACHUSETTS

ON READER-SERVICE CARD CIRCLE 3

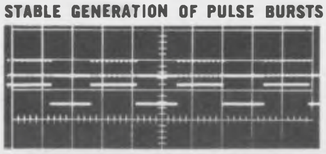
DATA SYSTEMS

PULSE INSTRUMENTATION

A Brief Case for a New Pulse Generator

MODEL: 101. PRICE· $395.00. DELIVERY: 4 weeks. MAJOR SPECS: rep. rates from 10 Hz to 10 MHz, single or double pulses, 5 ns rise time, simultaneous ±10V output, variable width and delay from 35 ns to 10 ms, duty cycles to 70%, ±250 mV trigger sensitivity, and both synchronous and asynchronous gating. ■ TYPICAL APPLICATIONS:

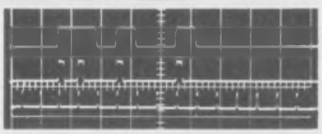
STABLE GENERATION OF PULSE BURSTS



Output
Gate

Output synchronously gated. 10 kHz pulse burst.

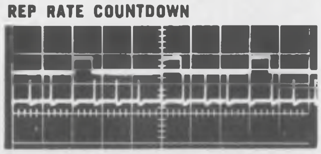
GATED DIGITAL SIGNALS



NRZ Information
RZ Derivative
Adv. Trig.

Output asynchronously gated against NRZ digital signals. Provides full control over RZ derivative. Advanced trigger outputs also serve as uninterrupted system clock.

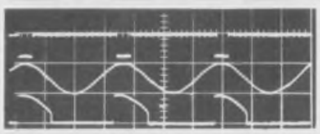
REP RATE COUNTDOWN



Output
Adv. Trig.

Output counted down from internal clock (or external triggers) for frequency division.

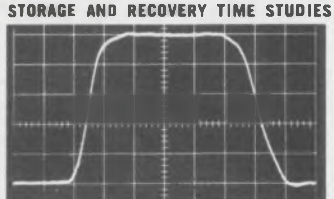
DESIGN OF POWER CONTROL CIRCUITRY



Trig.
Line
SCR

Output may be triggered from any point on an AC line voltage waveform. Allows phase control of SCRs, thyratrons, etc.

STORAGE AND RECOVERY TIME STUDIES



Clean pulses at 5 ns rise time. Horiz., 5ns/cm.

BEACON INTERROGATION

Unit No. 1
Unit No. 2

Outputs of two 101s shown. First unit determines pulse separation and pair separation. Second unit determines burst rate and pairs per burst.

EXTRA BENEFITS: Weight: 8 lbs. Height: 3½ inches. Width: 8½ inches. Rack mount two in 3½ inches of panel height. Rack mount for one unit leaves space for a data source or system control. ■ Convinced that the 101 offers champagne pulses on a beer budget? Ask for more evidence! See our Technical Bulletin 101 or a demonstration.

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ON READER-SERVICE CARD CIRCLE 4

VOL. 14, NO.

Electronic Design 24

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

OCTOBER 25, 1966

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. Application to mail at controlled postage rates is pending at Cleveland, Ohio and St. Louis, Mo. 59,721 copies this issue.

Expose it!
Peel it!
There's your working intermediate.
Draw on it!
Dry erase it!
Reproduce it!

No more wet processing.

Think of the convenience. Think of the time savings.

New CROLUX™ photopolymer reproduction film puts the darkroom really in the shade. With roomlight-handling CROLUX™ you get high-quality drafting intermediates right from your diazo machine or any other high-intensity UV light source.

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No more chemical eradicator. No more water.

That's right! Simply peel away a thin "negative" cover sheet to reveal a completely dry-erasable reproduction on dimensionally stable polyester drafting film.

No image deterioration.

Maximum image life. Superior shelf life.

CROLUX™ offers a reproduction with ink-like black lines on a clean background that will not darken or deteriorate with age.

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CROLUX™ has the world's finest matte drafting surface especially designed for graphite, plastic and combination pencils. Its "balanced tooth" is neither too rough nor too smooth—takes just the right amount of lead.

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Photo
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See CROLUX™ demonstrated at the
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DU PONT

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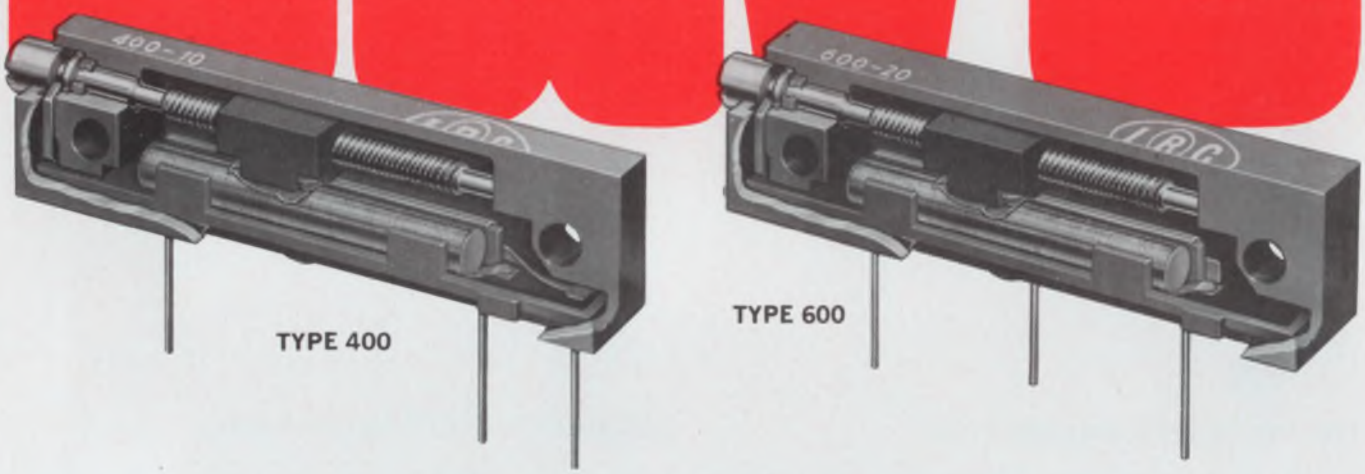


Military quality at industrial prices

IRC wirewound rectangular trimmers save space and dollars

IRC's CIRCUITRIM potentiometers offer MIL characteristics at the same price as industrial types. Benefit by upgraded performance and reliability for your industrial needs and impressive savings for your MIL applications.

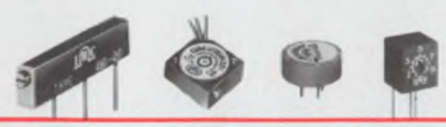
Both series are designed to perform under environmental requirements of MIL-R-27208. Molded diallyl phthalate cases are rugged, light and practical for use in any military or high grade industrial application. A one-piece, corrosion-resistant shaft and specially designed wiper block system isolate electrical elements and assure "set-and-forget" stability.

The 600 series is designed to MIL-Style RT-11 and is offered with staggered P.C. pins or teflon insulated leads. The 400 series is designed to MIL-Style RT-12 with P.C. pins in-line or teflon insulated leads. It is also available in a thin-line version of RT-11 (Type 400-20) with staggered P.C. pins which offer 30% space savings and complete interchangeability on pre-printed boards.

These low-cost MIL-type units are the result of IRC's years of experience in building high-quality trimmers. Samples available from local sales offices. For prices and data, write: IRC, Inc., 401 N. Broad St., Philadelphia, Pa. 19108.

ONLY IRC OFFERS ALL 4 POPULAR STYLES

Wirewound or infinite resolution elements



CAPSULE SPECIFICATIONS

	TYPE 400	TYPE 600
MIL STYLE	RT-12*	RT-11
POWER	1 W @ 70°C	1 W @ 70°C
TOLERANCE	± 5%	± 5%
RESISTANCE	10Ω to 50KΩ	10Ω to 50KΩ
TEMPERATURE	—55°C to 150°C	—55°C to 150°C

*Plus thin-line version of RT-11 (Staggered P.C. pins)

IRC

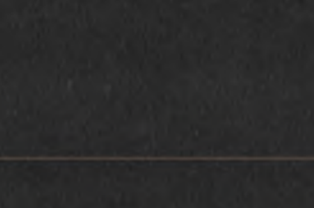
Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 6

Twenty-two new high voltage silicon transistors from

Voltages up to 700 and priced for your next application.

With voltages from 250 to 700 and 5 amps, this new Bendix B-176000 series of NPN silicon power transistors is made-to-order for breaking those tough voltage and gain problems—without breaking the budget.

There are 22 types, six designed specifically for high voltage fast switching applications. With matrices that let you pick the precise voltage and gain characteristics you require. No need to pay for an overspecified device.



The B-176000 series was designed to zero right in on the demands of CRT deflection circuits and line-operated inverters, regulators and amplifiers. The convenient TO-3 configuration makes them easy to use in many other applications as well. For complete details, write us in Holmdel, New Jersey.

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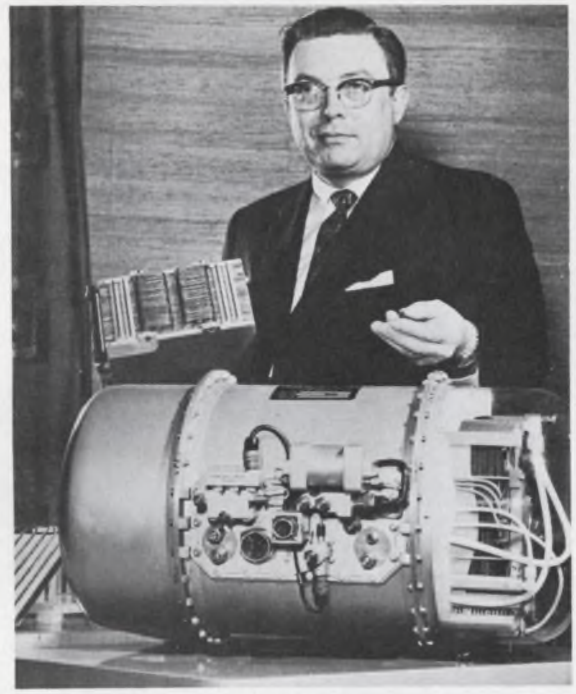
News

Scientists study use of computerized robots to search for life on Mars. Page 17.



Fuel cells are great—but still too expensive for commercial use. Page 26.

A 35-lb portable radar can detect a walking man a mile away. Page 40.

Also in this section:

News Scope

Electronic giants plan to build modern cities

Top executives of both General Electric and Litton Industries, among other large corporations, are planning to build entire cities with highly advanced technology. Construction won't start next month or even next year, but long range plans are being drawn.

The theory is that the giant, diversified electronics corporations are in an excellent position to support creative, imaginative city planning with the latest technological innovations and strong financial backing.

The president of Litton Industries, Roy Ash, told ELECTRONIC DESIGN: "We are developing and perfecting plans for a complete new city, but it is, as you can imagine, an extremely long-range plan." Informed sources say that Litton is hoping for some Federal support for its city. Reportedly Litton envisions a city that would have a population of around 20 million by the year 2000.

General Electric's plans for a city are being formulated at its Community Systems Development Div., Louisville, Ky. Industry reports are that GE is presently picking a site for the new city and plans to finance construction with its own funds.

The Goodyear Corp. is already planning construction of Litchfield Park, Ariz., a futuristic city 18 miles from downtown Tucson. The American-Hawaiian Steamship Co. is also reported to have similar plans at an undisclosed location.

Computers help locate 150,000 freight cars

One of the railroad industry's largest computerized communications networks, capable of pinpointing in a second the locations of 150,000 freight cars along 11,000 miles of track, will go into operation later this year on the Chesapeake & Ohio-Baltimore & Ohio Railroads.

The elaborate system consists of four Radio Corp. of America 3301 computers. Two of the computers will control a teletype message-switching system at the company's Huntington, West Va., facilities. They will be linked to another pair of RCA 3301's, which will handle message switching and also control an electronic car-tracing file at the C&O-B&O headquarters in Baltimore.

William C. Prinn, project manager for the affiliated railroad systems, said that more than 25,000 teletype messages a day are sent and received on nearly 700 teletype terminals on the railroad's network. The messages are concerned primarily with train and car movements, sales office reports, and the general administration of the railroad.

'Dead' lunar probe shows spark of life

After 86 days of silence, the nation's moon probe, Surveyor, came to life on Oct. 8, and began to send back signals to earth that described its condition.

According to a spokesman for the Jet Propulsion Laboratory, Pasadena, Calif., the probe's main battery is not dead, but it is far too weak to power the camera that successfully took 11,000 pictures of the moon's terrain.

Tracking stations for the Surveyor project were directed to cease operations early in August, because the mission was officially over. But a group associated with the project, led by Jay Holladay, a tracking network engineer, insisted upon making one last attempt to communicate with Surveyor. An antenna at Johannesburg, South Africa, transmitted the command that ellicited the response from the craft's telemetry equipment.

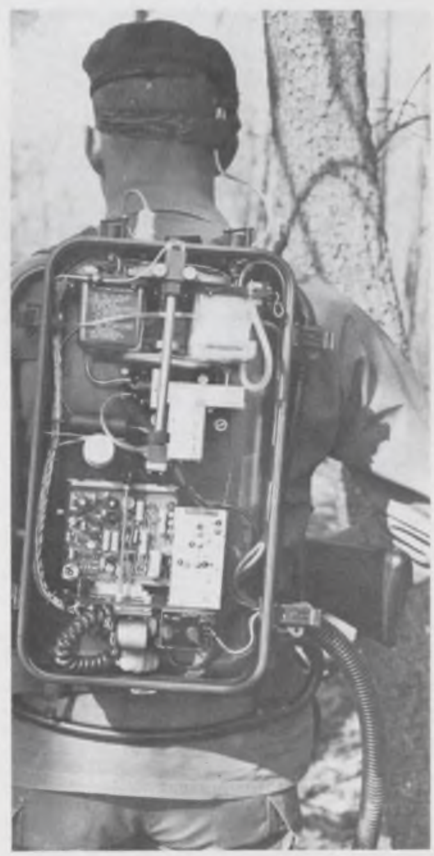
Then the engineers decided to use some power from the Surveyor's auxiliary battery to move its solar panel into a position from which it could draw more of the sun's energy. Later that day a tracking station at Canberra, Australia, detected some more signals.

Air sampler to help Army spot enemy

An electronic "bloodhound" may soon tell GIs on patrol in Vietnam if there are Vietcong around.

The Army Limited War Laboratory unveiled the Manpack Personnel Detector (E-63) at the annual meeting in Washington of the Association of the U.S. Army.

The unit is a lightweight point air sampling device. It "breathes" the air in the vicinity of its intake nozzle and forces it through a detection cell. The detection cell, which picks up "submicroscopic agents or particles given off by humans," puts



Portable electronic "bloodhound," developed by General Electric, tests the air for evidence of an unseen enemy and alerts the soldier-operator.

News Scope CONTINUED

out an electric alarm that alerts the soldier-operator. He can then search the area closely.

Work on the detector program has been carried out by the Ordnance Dept. of General Electric under direction of the Army at the Aberdeen Proving Ground, Md.

Satellites suggested for sea navigation

Navigation and communications for merchant vessels could be significantly improved, a consulting engineer believes, with a system of six satellites equally spaced in synchronous equatorial orbits.

Roy Anderson, consultant to the General Electric Co., suggested the scheme at a recent Institute of Navigation meeting at Kings Point, N. Y.

One main advantage of satellite communication for merchant ships, he explained, would be the virtual elimination of fading and blackouts in high-frequency communications.

Anderson said that it would cost only $2000 for the simplest fully automatic equipment to enable a vessel to obtain position fixes anywhere in the world from a satellite navigation and communications system.

Such a system, he added, could provide digital communications, such as teletype, as well as voice. The equipment, he said, would be comparable in cost to that of present ship communications systems.

Dyes in solution lase very brightly

Organic dyes in solution will bring the best of two possible lasers together.

Pumped by a large ruby rod, the high-power, pulsed output of the organic dye amplifiers exhibits extremely high spatial coherence and very low beam divergence. Ruby rods can amplify big pulses, but extreme spatial coherence has been observed only in gas lasers.

In addition the dye amplifiers can handle hundreds of megawatts of power and have recently achieved efficiencies of 50%, according to Dr. Peter Sorokin and Dr. W. H. Culver, experimenters at IBM's Research Div., Yorktown, N. Y.

The desirable property of spatial coherence means that the light is in phase across a plane perpendicular to the axis of the beam. This feature and the low divergence of the beam keep it intense and bright over long distances. This makes the organic dye amplifiers extremely useful for laser radars and range finders.

Lasing has been independently observed recently in two other laboratories, one at the Hughes Aircraft Co. and the other at the Institute of Physics and Chemistry, University of Marburg, Germany. The IBM developments are reported in the current issue of the IBM Journal of Research and Development.

Dr. Condon to head 15-month UFO study

Dr. Edward U. Condon, the theoretical physicist who played a key role in developing the first atomic bomb, will direct the Air Force-sponsored study of unidentified flying objects (UFO's).

The study will take 15 months and will attempt to determine if the UFO's are visitations from other worlds, as some observers believe. The Air Force has engaged the University of Colorado to conduct the investigation, and Dr. Condon will be acting in his capacity as professor of physics at the university.

It's Philco-Ford now, but same management

Philco Corporation has changed its name to Philco-Ford Corporation.

Robert Fickes, chief executive officer of the newly named Ford subsidiary, said that the management and corporate organization of Ford-Philco would remain unchanged.

The name change, he said "is intended to establish greater public recognition of the direct parent-subsidiary relationship of the two organizations."

'On target' laser sought for war communications

A method of keeping laser beams "on target" is being developed for communications between Army field commanders and their mobile computers. Laser beams are particularly attractive for combat communications, as they cannot be monitored inobtrusively by the enemy.

Though lasers, operating in the micron wavelength band, can transmit a great quantity of information at high speed, heat waves in the air and mechanical disturbances on the ground, such as bomb shocks, can throw the pencil-thin beam off its target, according to Gerard Ratcliffe, a research engineer at Sylvania, Waltham, Mass.

But if the transmitting beam is kept on target by a solenoid-controlled, gimbaled mirror, laser communications can be reliable.

The beam, diverging about 1/4 millisteradians, scans until it hits the target: a photoreceptor on the mobile computer. A corner reflector mounted in the center of the photoreceptor sends a small part of the beam back to the transmitter.

If the transmitter's image divider finds that the returning signal matches the transmission signal, the communication of information proceeds. Should the returning signal weaken, the transmitter's feedback circuit moves the mirror to strengthen it. Thus the beam is steered onto the target and continues to track it. The Sylvania system will tolerate random variations up to 1 degree.

Any interference, such as enemy deflection of the beam, instantly cuts off transmission. According to Ratcliffe, the system should be delivered to the Army by early 1967.

Long-distance computer aiding NASA engineers

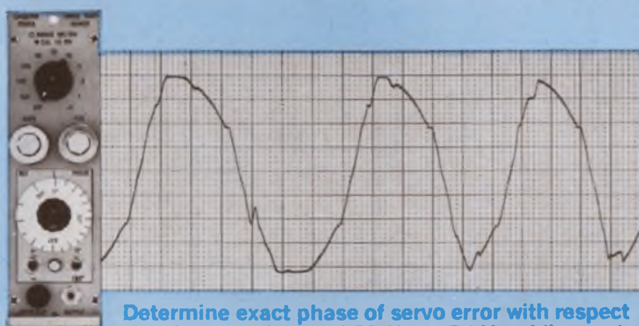
Engineers at NASA's Electronics Research Center, Cambridge, Mass. are now programing their complex space-flight problems into computers 2000 miles away at the Manned Spacecraft Center, Houston.

Known as the NASA Experimental Terminal System, the long-distance computer network is said to be the first NASA intercity large-scale computer network making use of Government-owned computers.

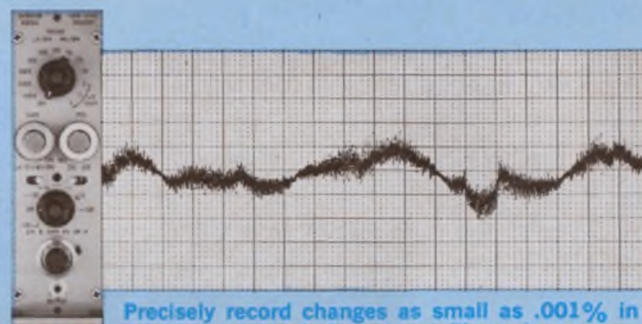
ON READER-SERVICE CARD CIRCLE 11 ➤

Bring on your complex, small, noisy, difficult signals.

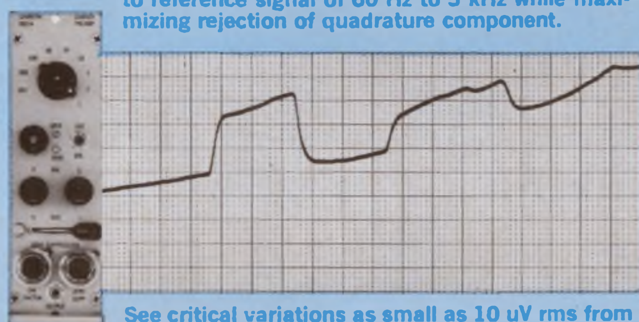
We'll give you traces that show them for what they really are.



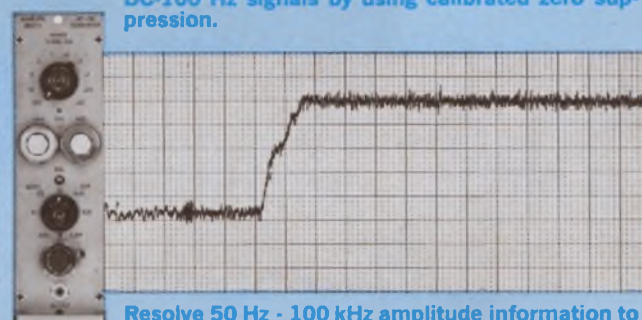
Determine exact phase of servo error with respect to reference signal of 60 Hz to 5 kHz while maximizing rejection of quadrature component.



Precisely record changes as small as .001% in DC-100 Hz signals by using calibrated zero suppression.



See critical variations as small as 10 uV rms from strain gages, other AC-excited transducers.



Resolve 50 Hz - 100 kHz amplitude information to 0.02% of full scale signals from 1 volt to 500 volts.

When you need the greatest possible degree of signal-conditioning precision and operational control, Sanborn 7700 Series oscillographs with solid-state "8800" plug-ins will give you chart recordings of *maximum resolution and intelligibility*.

Seven highly versatile signal conditioners offer unique performance capabilities: three DC types with a 1 uV - 250 V dynamic range, floating differential input and calibrated zero suppression . . . an AC-DC Converter with calibrated zero suppression and scale expansion permitting resolution better than 0.1%, 10 ms response and isolated, 1 meg. input . . . a phase-sensitive demodulator with calibrated reference phase shift, 90° calibrated dial with four quadrant selections, and a frequency range of 60 Hz to 5 kHz . . . a carrier preamp with 2400 Hz internal transducer excitation supply, calibrated zero suppression, cal. factor control and conversion gain of 10,000 . . . and a general-purpose DC preamp particularly useful for 100 mm wide chart recording.

Use any of these "8800" plug-ins in the 7700 thermal writing oscillograph matched to your packaging and channel requirements — 4-, 6- and 8-channel 7704A, 7706A and 7708A console types . . . 2-channel 7702A system in rack-mount or mobile cart versions . . . single-channel 7701A wide chart (100 mm) portable system. Every one of these thermal writers will give you permanent, rectangular-coordinate recordings whose resolution and accuracy make all your measurements more useful.

For a new brochure describing the advantages and wide choice of Sanborn thermal writing oscillographs, write Hewlett-Packard Company, Sanborn Division, 175 Wyman Street, Waltham, Mass. 02154.

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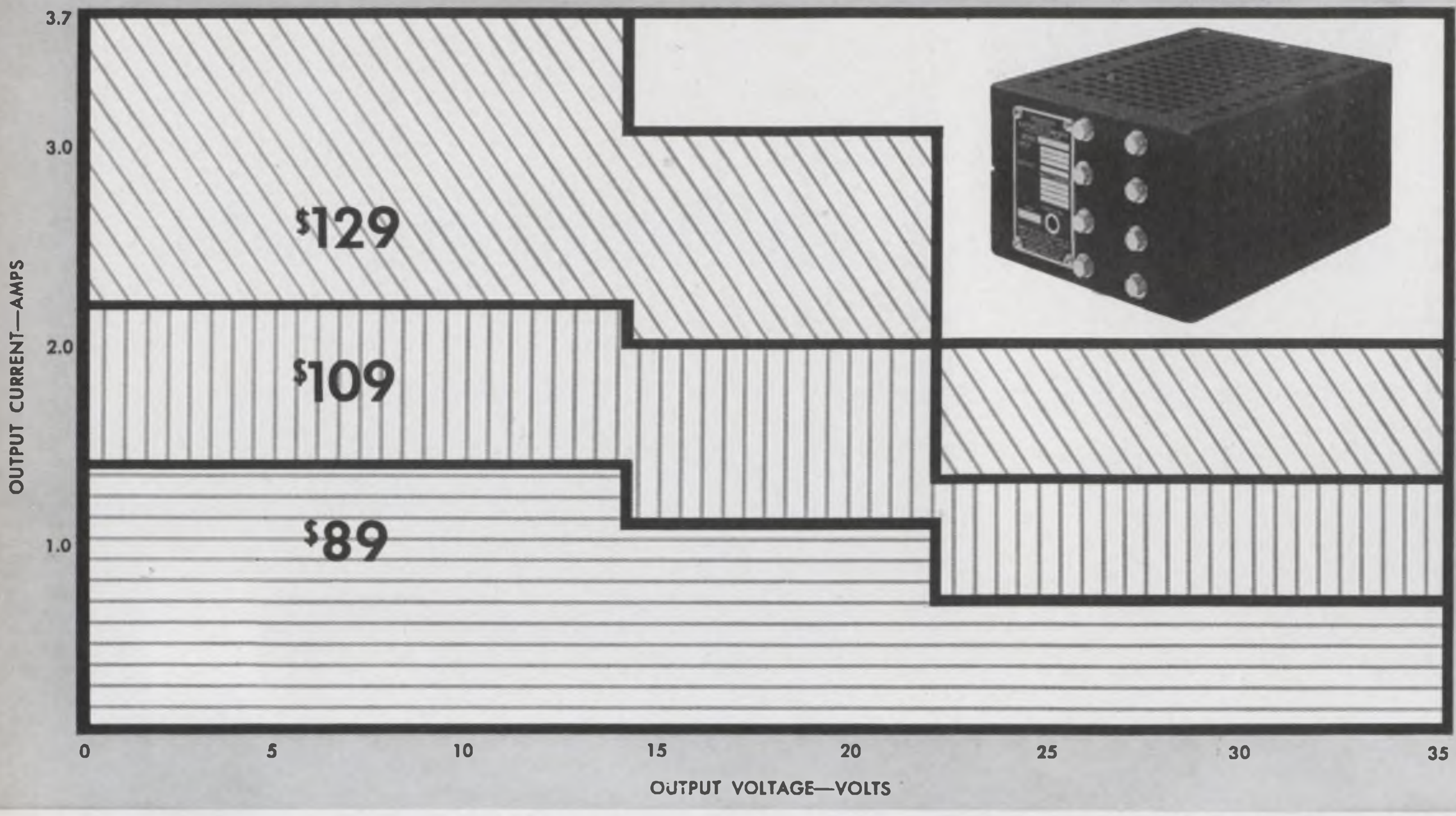

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RAYTHEON

Electronic frog eyes may search for life on Mars

Computer-controlled vidicons in moving robot may engage in extraterrestrial life hunt.

Roger Kenneth Field
News Editor

Some time after we land a man on the Moon, we will send a sterilized probe more than 34 million miles through space, soft-land it on Mars, and have it send back a description of any life or topographical features it finds. But NASA is evaluating scores of proposals from scientists and engineers now, even though the soft-landed probe may not be sent aloft until 1977.

One proposal, to be made by a group of scientists at MIT, would send a self-propelled probe, or robot, with highly advanced electronic visual-sensing and decision-making capabilities.

Such a robot would roll along or walk along the surface of Mars, and stop when it sees or hears something interesting. If the object that caught its interest moved, the robot could possibly follow it. If the object were a formidable barrier, the robot could back up and move around it. In any case, the robot would send back to earth only the information that described the interesting topographical features and distinctive sounds of Mars and, hopefully, any encounters with moving objects.

Since we know nothing about the nature of possible life on the big, red planet, we have no idea what or who might greet our robot. It could be anything from a few bacteria basking in the sun to a big, hairy, green arm.

The best tests, under these circumstances, are the most general tests: tests that make the fewest assumptions about life on Mars. And only the proposed visual tests are based on assumptions that are very nearly independent of the biochemistry of Mars.

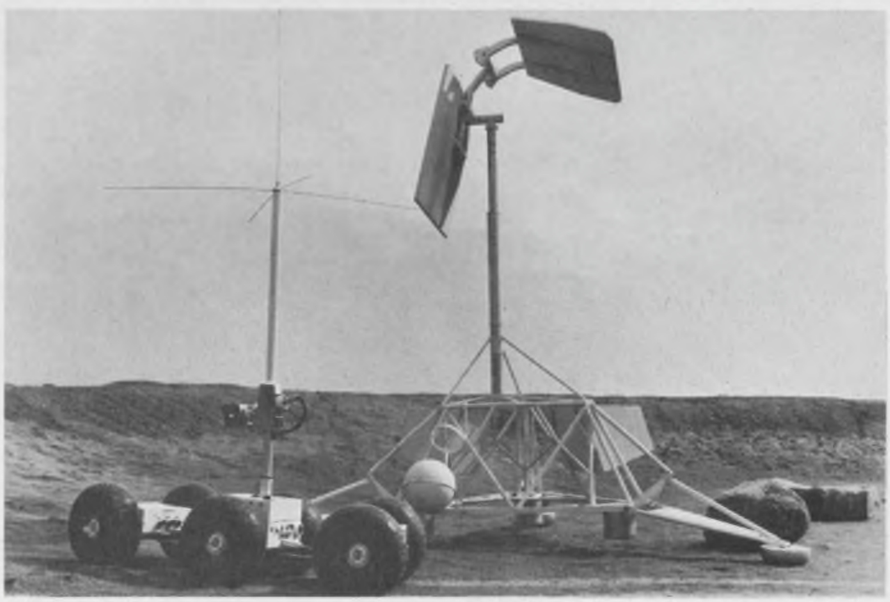
What is life?

Even life on earth has never been precisely defined. Scientists have noted both the necessary conditions for life (such as ability to reproduce) and the sufficient conditions (non-Brownian mobility is clearly indicative of life), but no single condition is both a necessary and sufficient condition for life.

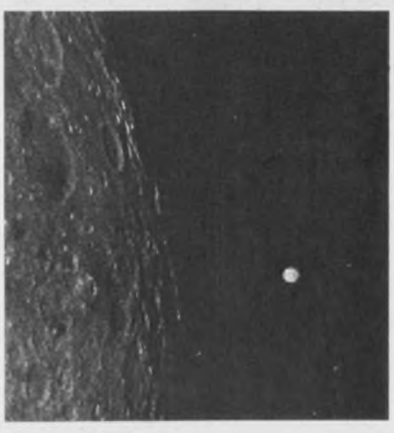
Regardless of just which tests we include in our probe, and whether or not we successfully answer the philosophic question, "What is life?", there is no doubt that our tests will have more meaning if many different sites are sampled.

Two companies have built self-propelled vehicles for extraterrestrial exploration. Bendix has designed a manned vehicle it calls the Local Scientific Survey Module. General Motors has built an unmanned vehicle that has a built-in stereoscopic vidicon system for guidance (see Fig. 1).

The great distance from earth to Mars (it varies from 34.5 to 250 million miles) presents a communications problem when a moving probe is used. Electromagnetic radiation, traveling at the speed of light (11 million miles a minute), takes from three to 23 minutes to make a one-way trip. When visual images indicate that the robot needs redirection to avoid impending danger, the signals from earth will reach it on the average of 30 minutes after the robot signals for help. A robot can walk over lots of cliffs in half an hour. There is little doubt that a moving probe must



1. **The Mars robot can have mobility** if it uses an extraterrestrial vehicle, such as this one made by General Motors. Behind it is Surveyor's frame.



The photograph on the cover shows the Moon in the foreground and Mars in the background. It is an unretouched photograph taken at the Lowell Observatory, Flagstaff, Arizona (colors added by artists). This shows the relative distance from the Moon to Mars.

(**search for life,** *continued*)

carry a considerable decision-making capability.

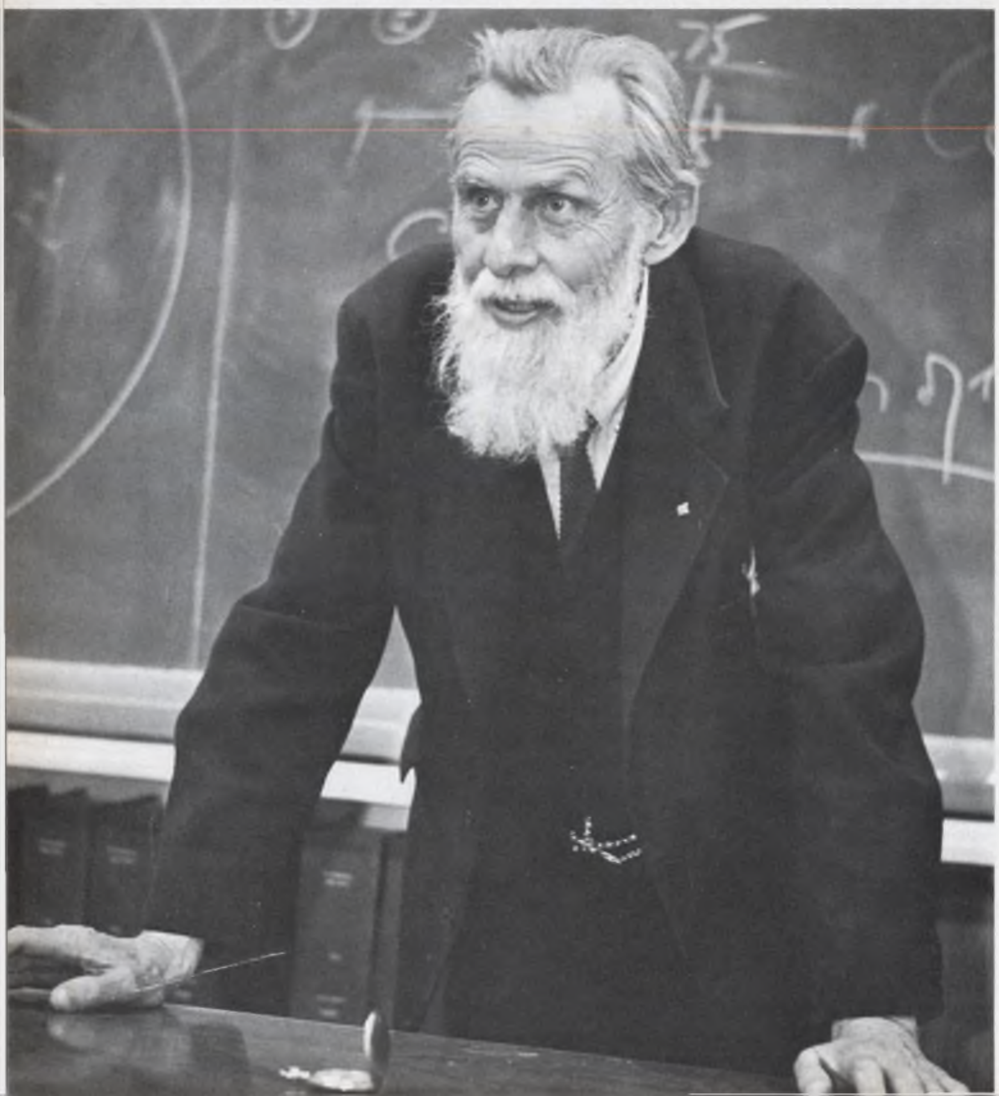
For the past three years Dr. Warren McCulloch, a neurophysiologist and Louis Sutro, electrical engineer, have studied at MIT the role to be played by artificial visual perception in the exploration of Mars.

"We cannot yet describe the operation of a human brain well enough to fashion a computer after it," says McCulloch "so a natural step would be to use the computers we have, and put more logic in the robot's eye. This is just what happens in lower forms of life. A primate's eye is far less complicated than a frog's eye, for example.

"A human brain carries out logic or reasoning in three ways: deductive, abductive and inductive. Its deductive logic is evident when it compares a particular case to a general rule and makes a decision. Its abductive logic is effected when it weighs a number of factors and arrives at a decision that maximizes the probability of an advantageous outcome. These two types of logic can be simulated by a computer, but it is helpless when it tries to reason inductively. A man will reason meticulously to a point, but a good mind will suddenly leap to the creation of a hypothesis. It's that final leap that gets you when you try to simulate a brain with a computer. Without inductive reasoning we can only make very stupid computers, and we don't yet have the mathematics to describe the process of inductive reasoning. We must be content to simulate lower levels of intelligence. That puts a greater importance on the visual system."

McCulloch believes that the studies of the frog's eye, presently underway at MIT, will be useful in understanding the operations of any eyes in nature. "The frog's eye is complicated," says McCulloch, "and if we understand it thoroughly and build a working model of it, we should be able to understand and approximate the other eyes quite easily."

A team including physicist Dr. Roberto Moreno-Diaz, Richard Warren and Louis Sutro have been collaborating for many months to duplicate the frog's eye with available electronic components. Moreno-Diaz has arrived at a functional model of the eye, and to it he has correlated a model that might be implemented with electronics (Fig. 2a, b). Some time ago, Warren demonstrated feasibility by simulating part of an eye and its logic on one of the Institute's computers along with a simulated "scene." Recently the group has experimented with actual hardware consisting of a stereoscopic vidicon camera.



Dr. Warren McCulloch discusses proposed plans for the search for extraterrestrial life on Mars. His ideas are the basis for much of the work being done at MIT's Electronic Instrumentation Laboratory.

Ganglion cell simulated

The particular part of the frog's eye they simulated is the bug-detecting ganglion cell—four sets of ganglion cells actually detect these patterns: edges, over-all dimming, any time-varying visual event, and movement of a dark convex edge (bugs). This bug-detecting ganglion, according to the MIT scientists, has a rather complex response. It responds to an object that moves centripetally into the field of the retina provided that the object is relatively small, is darker than the background, and has a sharp leading edge.

The bug-detecting ganglion cell does not respond to a moving straight edge, changes in level of illumination, changes in the speed of an object, amount of contrast, or light-colored moving convex edges.

The model of the cell in Fig. 2a calls for a layer of bipolar cells connected to a layer of photoreceptors by two delay lines. One line delays the signal more than the other and the off-bipolar cells only trigger if the leading signal is weaker than the trailing signal. This corresponds to a dimming of the photoreceptor. Other on-bipolar cells trigger in response to brightening.

The output from each bipolar cell is a pulse of unit amplitude, r. In level 1, the storage fibers lengthen the pulses from the responsive retinal field, R_1, allowing them to per-

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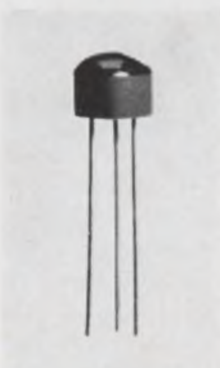

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ON READER-SERVICE CARD CIRCLE 13

(**search for life,** *continued*)

sist. This permits the comparison of many pulses that may not have originated at precisely the same time.

At level 1(b), the pulses of unit amplitude are divided by an amount proportional to the number of photoreceptors being dimmed by the leading edge of the image.

Layer 2(a)* takes the output of level 1 and compares it with the total number of photoreceptors that have been dimmed. In effect, it divides D_1, the total area of dimming, by d_1, the length of the leading edge. The fraction D_1/d_1 is a measure of the penetration of the bug into the frog's field of view. Level 2(a) performs the same function for photoreceptors that lie in R_2 but outside the responsive retinal field, R_1.

Level 3 simply stores and sums the pulses from the on-bipolar cells in R_1. These cells respond only to brightening, and not to dimming.

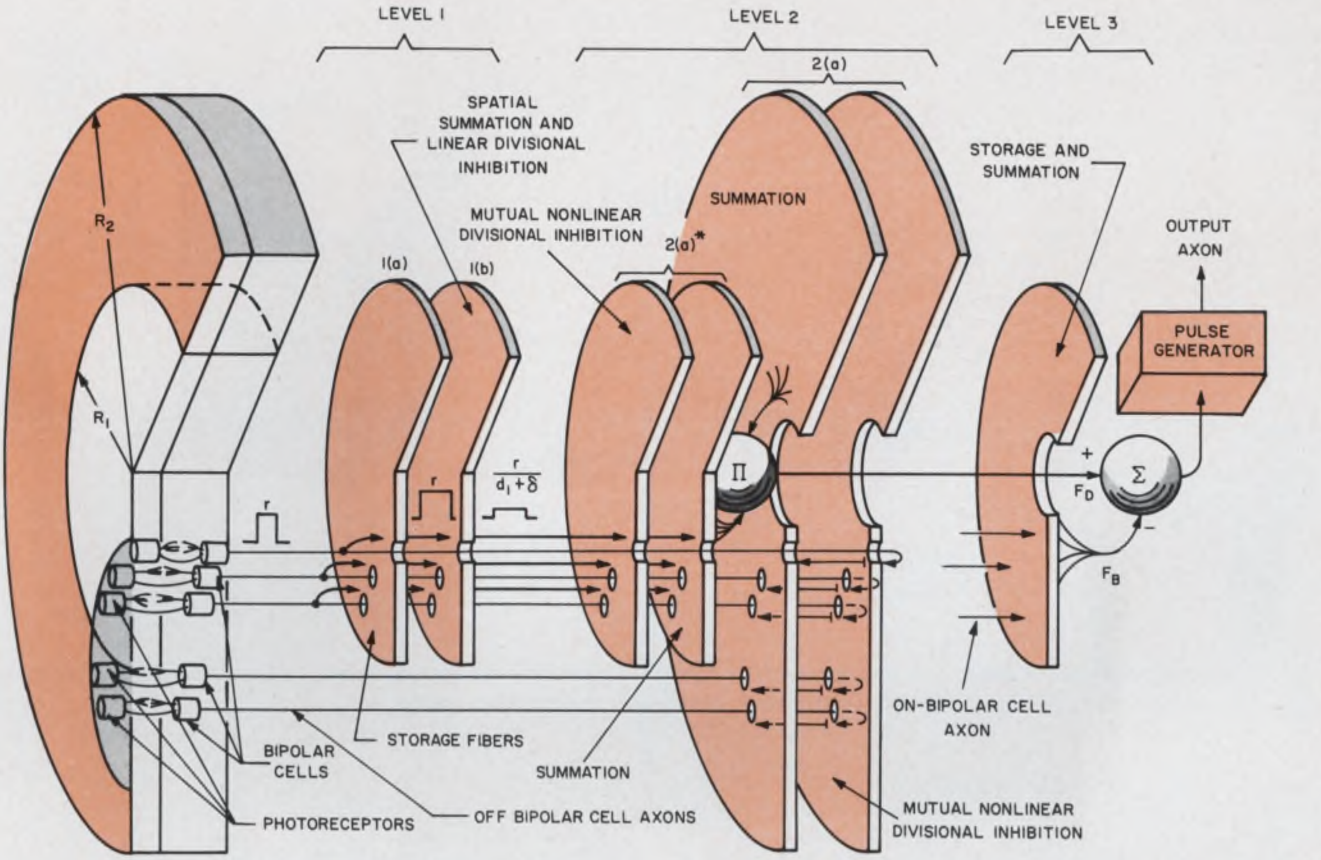
This information, together with all the information about the dimming patterns emanating from the II multiplication operator between level 2(a)* and 2(a), is fed to a pulse generator. It responds if, and only if, a dark round object subtending between 3° and 5° at the eye moves centripetally into the field of view.

An electronic frog eye

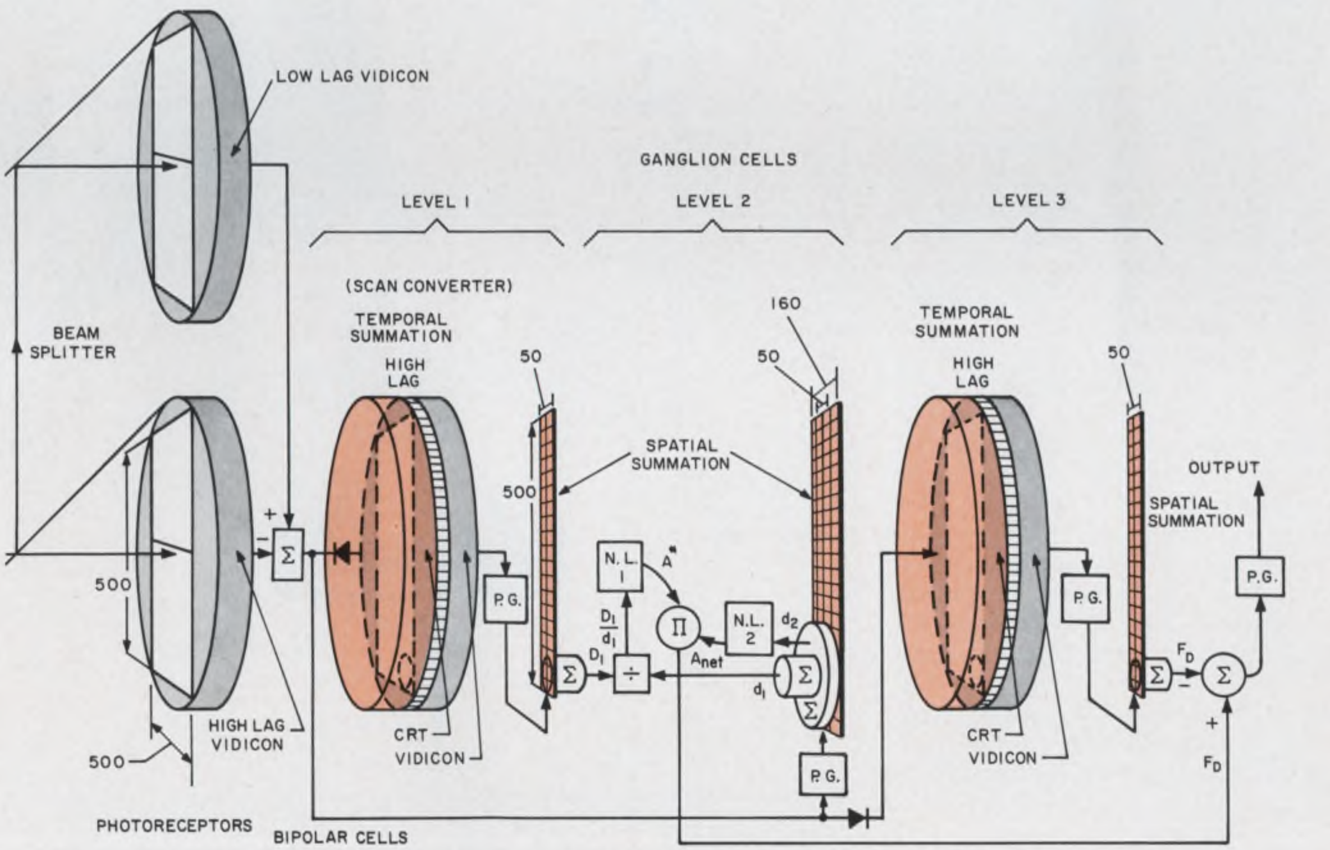
Moreno-Diaz and Sutro have collaborated on a functional model of the possible electronic instumentation for this bug-detecting ganglion cell (see Fig. 2b).

A beam splitter and two vidicon tubes simulate the photoreceptors in the frog's retina. The frog's delay lines are approximated by using two vidicon tubes that each have photosensitive surfaces of different lag times. A point-to-point summer and two diodes send dimming traces to the scan converter in level 1 and brightening traces to the corresponding unit in level 3. Persistence of trace in the scan converter's CRTs and high lag in their vidicons enable them to arrive at a value for D_1, the total area of dimming. The CRTs and vidicons in the converters are attached by fibre optics.

The logic in level 2 performs the

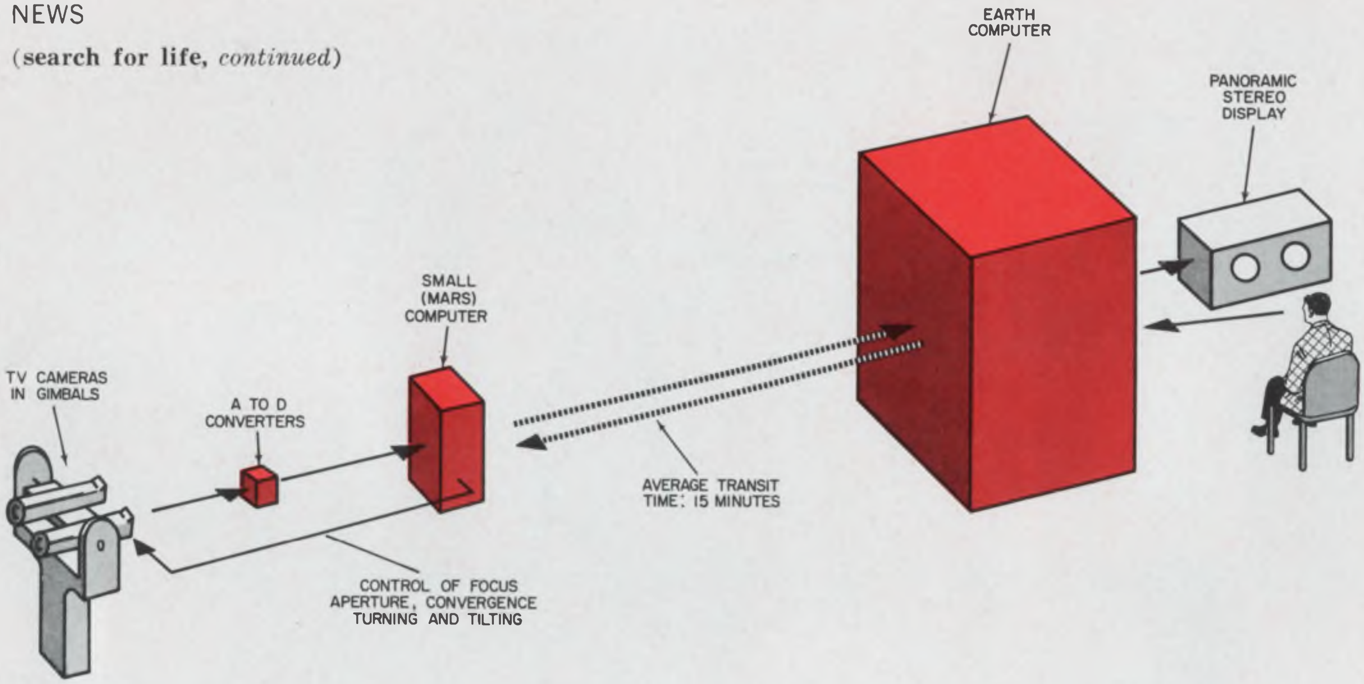


2a. **Model of the bug-detecting ganglion cell** in a frog's eye. The dark area at the left is the image of a bug moving centripetally into the eye's field of view. Delay lines connect photoreceptors to bipolar cells.



2b. **Electronically simulated** bug-detecting ganglion cell. A limited number of copies of the paper that describes these models in detail is available. Single copies will be sent to readers who circle Reader-Service number **150.**

(**search for life,** *continued*)



3. **Stereoscopic vidicon** is controlled and focused by computer in robot. The robot's computer could save much time by making decisions without consorting with earth computers or people.

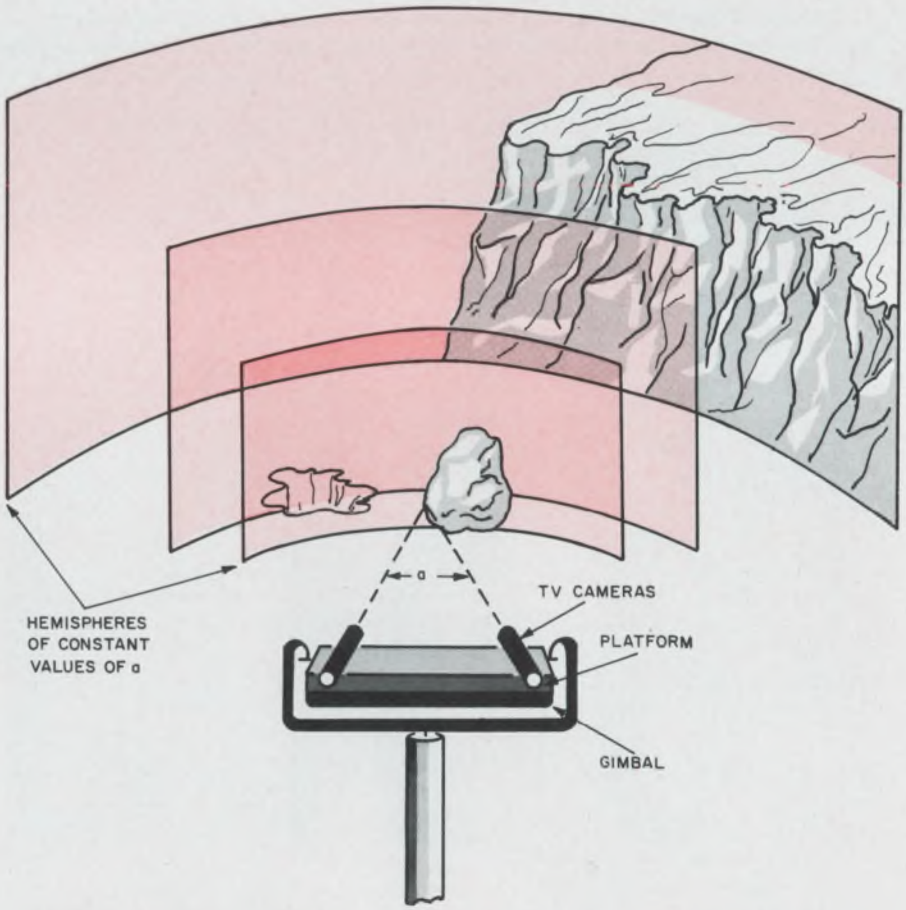
same kind of division, summing and nonlinear inhibition as the layers in the model frog's level 2.

The group proposes to make the logic with integrated circuits, and if its development is rapid enough, use solid-state vidicons for the photoreceptor layer. Westinghouse and RCA are actively engaged in the development of these devices and the MIT group has experimented with the Westinghouse units.

The MIT scientists are now building a stereoscopic vidicon camera with interchangeable lenses. It would be mounted on a platform that has three degrees of freedom. It would be connected to a small Mars computer, which, in turn, would control its focus, angle of convergence, and direction of aim (see Fig. 3). Such a unit would scan a scene and select only the distinctive topological features for transmission back to Earth (see Fig. 4).

The decision-making equipment will be a series of small integrated computers. They will evaluate all information coming from the camera and select one of a number of possible courses of action of the robot. Dr. William Kilmer, consulting at MIT, proposes the following:

Advance to ____.
Turn right.
Turn left.
Right itself (after overturn).



4. **Platform with stereovidicon** scans imaginary hemispherical shells for contrasting edges. When it finds one, such as this rock, it then proceeds to transmit back to earth pictures of the object. When the computer finds a line in corresponding frames on the vidicon, it traces that line, end to end, around the object. In this way it can seek out and identify salient details of a scene.

(search for life, *continued*)

Perform experiment 1.
Perform experiment 2.
Maintenance cycle.
Communicate mode 1.
Communicate mode 2.

The small computers in the robot that issue these commands would check each other and continuously "vote" on the order of importance of all possible commands. The computers would either be interconnected, or they would actually time-share one complex computer.

Certain over-all modes of operation would have priority, like "righting after overturn," and certain problems could be sent to earth for decisions by either a giant computer or by men.

Chemical tests use electronics

Besides the frog's-eye investigation, NASA is supporting the development of more conventional tests for life. Dr. Carl Bruch, the biologist who until recently headed NASA's search for extraterrestrial life, has compiled a report of many such tests. For example, gas chromatographs of the pyrolytic products could identify proteins, lipids, carbohydrates, peptides and possibly even nucleic acids. Mass spectrometers, visible-light spectrophotometers, ultraviolet spectroscopes and equipment to measure optical rotation could detect these substances, which are common to life on earth. This report appears in a book entitled *Biology and the Exploration of Mars*, National Academy of Science, Washington, D. C.

One of the most interesting tests simulates the glowing tail of an ordinary firefly. The glow is due to a chemical reaction between lucerferin, luciferase, magnesium ions, oxygen and adenosine triphosphate. The space probe could be set up to carry all of the firefly chemicals except the phosphate compound. The presence of the compound in a sample gathered on a planet would complete the chemical reaction, and a glow would result. A simple photomultiplier could detect this light and relay its presence to earth. Adenosine triphosphate is found in all cellular material, and its presence would strongly suggest life. ■ ■

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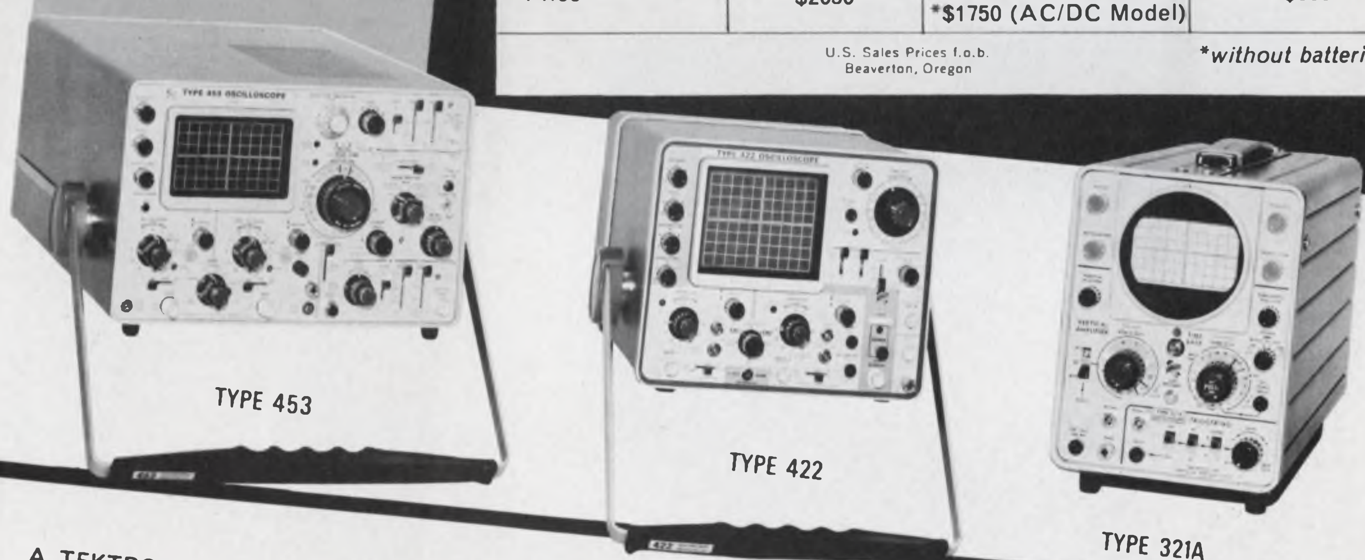

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ON READER-SERVICE CARD CIRCLE 17

High costs still bar commercial fuel cells

Cheaper components and elimination of platinum as reaction catalyst are called major problems.

Neil Sclater
East Coast Editor

The fuel cell, often heralded as the possible successor to the battery, has a long way to go before it becomes an important commercial power source. Experimental fuel cells are already used in spacecraft and are economically feasible for military, ocean and remote-area applications. But they are still too expensive for domestic use. These opinions were stated by speakers at the recent National Electronics Conference in Chicago.

The first practical use of an experimental fuel cell by the Army in Vietnam is expected within the year.

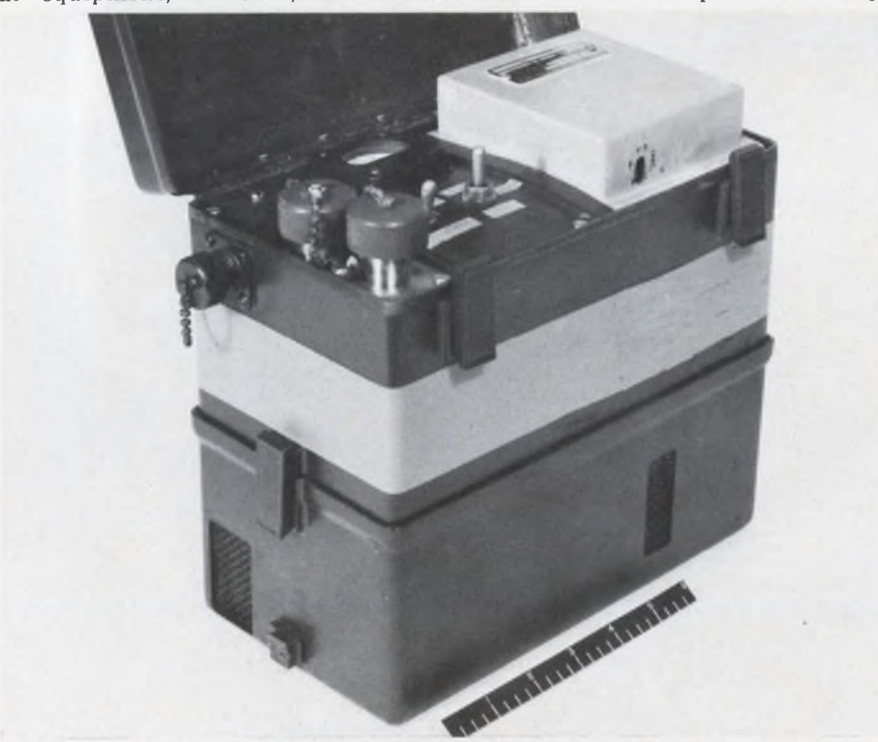
The excessive cost of power from fuel cells can be accepted in space, military and remote-location applications. For powering commercial vehicles and industrial equipment, however, the cost per kilowatt hour is still excessive, and not yet competitive with conventional batteries.

Two views on the problem

According to one engineer, John Moncrief of the U.S. Army's Electronics Command, Ft. Monmouth, N. J., the practical use of fuel cells depends on decreasing the costs of pumps, heat exchangers and accessories. He believes that this will come about with increased production.

Another engineer, Roy Mushrush, manager of General Electric's Direct Energy Conversion Operation, Lynn, Mass., views the problem as one of reducing or eliminating the use of platinum as the reaction catalyst within the fuel cells.

The fuel cell has most of the advantages of a battery. It is compact, has no moving parts and is silent. It is also capable of steady electrical output without recharging, has long life and in most cases can operate on air and conventional fuels. It makes more efficient use of conventional fuel than conventional generators, by converting the energy of fuel oxidation directly into electricity (30% to 50% vs less than 20% for most conventional converters). Finally, fuel cells do not give off noxious fumes.



Army's hydrazine/air fuel-cell system can supply 28 volts. The unit, made by Monsanto Chemical Co., has a 12-hour fuel supply. With electrolyte, it weighs 12 pounds. Internal gas pressure produced by internal electrodes forces the fuel into the electrolyte. Used with a nickel-cadmium battery in a matching case, the fuel-cell system becomes a 60-300-w hybrid.

These qualities, according to Moncrief, are attractive to the Army and justify the high cost of the devices. Moncrief says that the Army would like to reduce the necessity for shipping vast quantities of fuel to overseas areas and believes that fuel cells could help by making more effective use of the fuel shipped.

The most advanced fuel cell systems now operating are in the Gemini spacecraft. They convert hydrogen and oxygen directly. The Army is about to give an actual combat-condition field-test to small portable systems using direct liquid fuel, hydrazine, and air. The nitrogen in the hydrazine (N_2H_4) is merely vented to air after the reaction, leaving water as in the hydrogen-oxygen system.

Hydrazine is an expensive fuel at the present time, but the Army considers this a first step toward utilizing more common standard hydrocarbon fuels or gasses.

The Army plans to test a 60-watt hydrazine fuel cell in parallel with a 300-watt nickel-cadmium storage battery. This hybrid system, to be used to power radio transmitters, will weigh about 22 pounds and will have a volume of 0.5 cubic foot.

The battery supplies most of the short-duration load (up to 300 watts) and the fuel cell provides stand-by power and recharges the battery.

Moncrief says that, except for some experimental vehicular applications, nearly all of the planned uses of fuel cells are related to powering portable, mobile or remotely-located electronic

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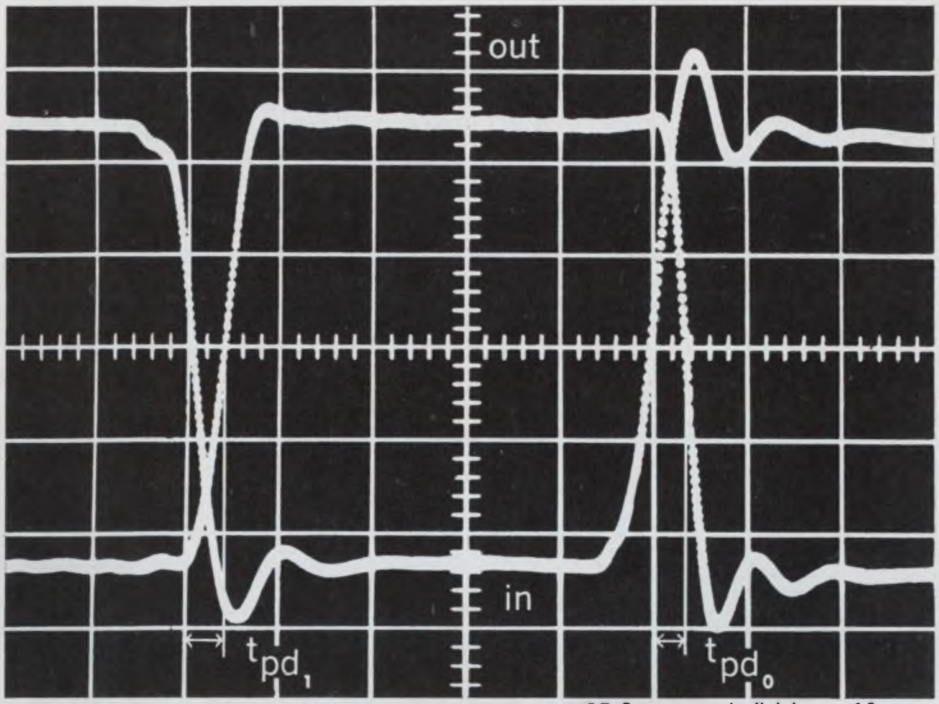

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(**fuel cells**, *continued*)

equipment.

He says that the U.S. Government has been spending over six million dollars per year for the past few years on fuel-cell research and he estimates that industry has been investing about three times that amount.

The fuel cell, despite some advance publicity, has a place as a direct-power source, but for the foreseeable future it will not dominate the power-source field. In fact, it is quite likely that the first practical, commercial fuel cells will be hybrids similar to that used by the Army.

Moncrief reports that the hydrogen/oxygen system is fully developed and available for space applications. For ground use it will be available in about a year. He also says that hydrogen/air systems are progressing satisfactorily but that they are inherently less efficient because of the low percentage of oxygen available in air.

Hydrazine/air systems capable of producing 500 watts will reach the production stage in 1968, Moncrief predicts. Indirect hydrocarbon/air systems, including natural-gas types, could be produced by 1970. He says, however, that the real objective of the fuel-cell R&D is to produce hydrocarbon/air fuel cells that use standard fuels and are capable of 15 kW. But this is still 10 years away, he adds.

Mushrush told the conference about heat rejection. He said that low-temperature systems require much bigger radiator surfaces and these add weight and complexity, particularly for applications such as spacecraft. The high-temperature systems require less radiation surface, so that fuel-cell development is aimed toward higher-temperature reactions.

The cost of materials for fuel cells is another major handicap in their transition to commercial production. Fuel cells for space and high-power applications make use of large quantities of platinum and, in order to be commercially acceptable, it is almost mandatory that the amount of costly platinum be reduced or eliminated.

So far, no one has found a good substitute for platinum. The design direction that has been taken has been toward fuel cells that function without platinum. For example, alcohol systems operating at approximately 1000°F could use nickel as a catalyst successfully.

Mushrush said that General Electric is working on fuel cells for space, land and sea operation. The company recently announced a buoy-type fuel cell that is roughly the size of a 2-ft cube. It is capable of operating under water at depths of up to 400 ft. Completely self-contained, it does not require external fuel.

Platinum is not a significant factor in this design because of its relatively small 5-watt-average, 500-watt-peak power output. Both fuel cell specialists agree that the best prospect for the fuel cell in the near future is a hybrid combination with conventional batteries. ■ ■

How the fuel cell operates

A fuel cell is an electrochemical device that continuously changes the chemical energy of a conventional fuel and of oxygen into low-voltage direct current. Simply, it produces electric power directly from a continuous chemical reaction.

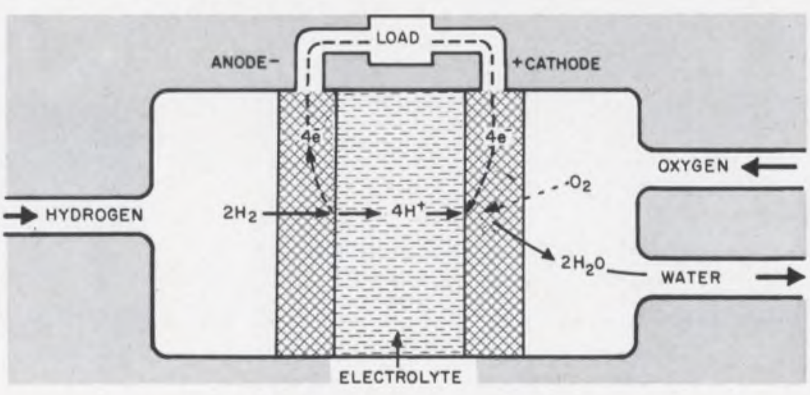
The fuel cell, like the battery, has an anode and a cathode. As shown in the diagram, they are joined both internally and externally. Electrons flow from the fuel in the external circuit and ions pass between the electrodes internally through the electrolyte.

A conventional battery stores energy but does not convert it. It is limited by the amount of its primary charge and the need for periodic recharging. The fuel cell, however, operates as long as fuel and oxygen are supplied.

The hydrogen-oxygen fuel cell reverses the process of electrolysis. Instead of breaking down water into its components by passing an electric current through it, water is formed in the fuel cell by a chemical reaction that liberates electrical energy.

The typical fuel cell with an acidic electrolyte is shown here. Hydrogen reacts at the anode to give up an electron (e−) to the load while simultaneously releasing hydrogen ions (H+) into the solution. At the cathode, those hydrogen ions combine with oxygen and the electrons from the load circuit to produce water.

Migration of both electrons and ions maintains internal and external charge and material balance. If the electron flow in the external circuit or the ion flow in the internal circuit is interrupted, power output will cease. Breaking the external electrical circuit essentially stops the use of fuel. Other fuels besides hydrogen may be used directly in certain fuel-cell systems. These include propane, methyl alcohol, ammonia and hydrazine.



ANODE $2H_2 = 4H^+ + 4e^-$

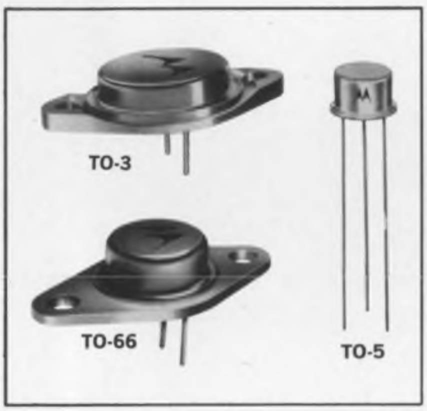
CATHODE $O_2 + 4H^+ + 4e^- = 2H_2O$

RESULT $O_2 + 2H_2 = 2H_2O$

Semiconductor Report

SILICON POWER DEVELOPMENTS FROM MOTOROLA

NOW, PNP SILICON POWER TRANSISTORS TO 30 AMPS . . .



An industry "first", Motorola's new 30-amp PNP silicon power transistors let you choose the optimum device for your application from the widest array of PNP transistors available — with collector currents ranging from 1 to 30 amps in three package configurations!

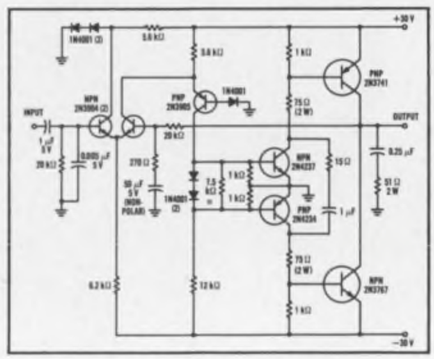
Use these PNP silicon devices for direct replacements of germanium transistors in existing sockets or with Motorola NPN silicon types to provide efficient low-cost, reliable complementary circuits. Both PNP and NPN categories are available in these premium and economy versions: **Circle Reader Service No. 108**

CASE TYPE	P_D @ 25°C case	I_C(max) (cont.)	PNP	NPN	Typ h_{FE} @ I_C	$V_{CE(sat)}$ @ I_C
PREMIUM TYPES . . . V_{CEO} — 60 & 80V						
TO-3	200W	30A	2N4398-99	—	15-60 @ 15A	1.0V @ 15A
	150W	10A	2N3789-90	2N3713-14	25-90 @ 1A	1.0V @ 5A
			2N3791-92	2N3715-16	50-150 @ 1A	
TO-66	20W	3A	2N3740-41	MJ5203-04	25-100 @ .50A	0.6V @ 1A
TO-5	5W	1A	2N4235-36	2N4238-39	30-150 @ 0.25A	0.6V @ 1A
ECONOMY TYPES . . . V_{CEO} — 40 & 50V						
TO-3	175W	30A	MJ450	—	20 min @ 10A	1.0V @ 10A
	120W	15A	MJ2901	MJ2801	15-60 @ 8A	1.5V @ 8A
	80W	5A	MJ490	MJ480	20 min @ 2A	1.0V @ 2A
TO-66	20W	3A	MJ3702	MJ5202	20-100 @ .50A	0.6V @ 1A
TO-5	5W	1A	2N4234	2N4237	30-150 @ 0.25A	0.6V @ 1A
			MJ430	MJ440	25-150 @ 0.25A	0.5 @ 0.75A

ELIMINATE TRANSFORMERS, CUT COSTS WITH ECONOMICAL PNP/NPN COMPLEMENTARY CIRCUITS!

You can design direct-coupled complementary circuits which eliminate expensive transformers and reduce costs by combining Motorola PNP and NPN silicon power transistors. Complementary designs furnish a high degree of frequency stability and reliability as well as the ability to drive both ac and dc loads.

The 10-watt servo amplifier below exemplifies the many applications which can be served by complementary circuitry. Higher power outputs can be achieved with minor circuit modifications and by the substitution of components capable of handling greater power.



*It may be necessary to adjust this resistor to establish proper quiescent current (10-30mA) in the output stage.

COMPLEMENTARY SERVO AMPLIFIER

Driving 20Vrms into a 40Ω load, this circuit provides a 10W output. The voltage-gain is 37dB ± 1dB (at 25°C). "Gain" variations are less than ± 0.5dB (from −55 to +100°C). Power-gain is 60dB (min). The circuit has a 15KΩ input-impedance while its output-impedance is under 1Ω.

NOTE: All resistors ± 5% – ½ watt (unless otherwise specified).

Motorola has prepared an informative series of Application Notes on both audio and servo amplifier complementary circuits. These comprehensive reports are yours for the asking. See your local Motorola representative or write: Technical Information Center, Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

Circle Reader Service No. 109

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Speed Inquiry to Advertiser via Collect Night Letter

"Technical Marshall Plan" for Europe?

Washington Report

S. DAVID PURSGLOVE,
WASHINGTON EDITOR

"Technical Marshall Plan" studied

Electronics and fields that rely heavily on electronics are key features in a so-called "technical Marshall Plan," now getting serious study at the State Department and at the White House Office of Science and Technology. Proposed by Italian Premier Amintore Fanfani, the plan is designed partly to help nations that lag behind the industrial leaders, but mostly it would help pull the Atlantic Alliance back together through a major effort in which NATO nations could cooperate.

President Johnson has expressed basic agreement with the plan and has asked several panels to study it. In its first phase, the plan would transmit U. S. technology to other NATO nations. In its second phase, the upgraded technology of NATO countries would be transmitted to lagging Eastern European nations. This, Fanfani believes, would be a major step toward bridging East-West differences and perhaps open markets in both directions.

Fanfani has approached all NATO nations with the proposal, but the U. S. would bear the burden of transmitting technological knowledge and hardware, just as it shipped agricultural and construction knowledge, food and hardware under the original Marshall Plan. The new plan calls for assistance in six areas: aeronautics, computers, space research, satellites (for scientific, industrial and commercial purposes), atomic and fossil-energy research, and environmental health and resources, including water desalination and air and water-pollution technology.

Officials at the State Dept. and the Office of Science and Technology are generally pleased with the basic outline of the plan, partly for the international political opportunities it presents but largely for the opportunity it offers to generate world-wide markets for several emerging technologies. A Pentagon official put the Defense Dept.'s position this way: "This isn't our bailiwick, and I don't think we have an official position, but I think it's a great opportunity for a lot of companies that are going to have to start worrying pretty soon about what happens when we get things cooled off in Vietnam."

Industry awaits EROS progress

Industry will have but a small role, if any, in the preliminary design of the Interior Dept.'s Earth Resources Observation Satellites (EROS). Studies on the feasibility of the program are under way. They are to be completed this year. A sampling of electronics and aerospace industry representatives shows no widespread unhappiness however. The representatives point out that no funds of any consequence will be available until late next year. Besides, one added, "We want to let the Interior fellows spend their own money, making sure they will really go ahead with this thing, before we start plowing our funds into proposal-making."

Interior says a typical EROS will weigh a half ton and likely be put into orbit atop a Thor-Delta rocket. The first launching is tentatively set for 1969, and the estimated cost of the program to that time is about $20 million. The program is similar to one started at the Agriculture Dept. There, under a NASA contract, officials are taking a low-priority look at the potential for satellites to help underdeveloped nations increase food production and develop their natural resources. Both Agriculture and NASA officials expect that optical and electronic sensors, can be used to identify the types, conditions and extent of agricultural and forest soil, water and crops. Early stages of what could, without proper action, become widespread plant diseases or insect infestations would be detected. Agriculture's program is being pushed by the Agriculture Research Service and the Forest Service.

Interior's program stems from considerable work already performed in the U.S. Geological Survey, and the EROS project is headed by Dr. William T. Pecora, director of the survey agency. He contends that high-altitude satellites, equipped with appropriate sensors could not only examine large land masses and simultaneously compare conditions in one area with those in another, but that they could also enable researchers to "see" more easily beneath water, forest and earth cover. First priority among the EROS anticipated missions seems to have gone to advanced cartography, according to Pecora.

The first EROS will have, Dr. Pecora anticipates, an optical photo system coupled with "a small telecommunications unit, so that we may relay data to and from ground stations that will aid in interpreting the television images."

Submarine identification plan scuttled

Why did the Navy strongly urge the Pentagon and State Department to turn down the proposals of some of its own senior officers to set up international underwater Submarine Defense Identification Zones similar to the Air Defense Identification Zones? One Defense Dept. official says both submariners and the Intelligence community feared that the Navy might be its own chief victim of such an agreement. Under the air-defense zones—and presumably the submarine would follow the same basic lines—nations have the right to challenge aircraft headed toward their shores long before 3-mile or 12-mile limits are reached. But submarines patrolling near or in other national waters are among America's prime sources of intelligence on foreign shipping and naval maneuvers and shore activities.

Although the proposed Submarine Defense Identification Zones would have set up two major commands—East Coast and West Coast—that would have manned much advanced gear, largely electronic, the same international agreements that would have allowed the U.S. to challenge submarines headed in our direction would have permitted other nations to challenge our own craft.

So far as Pentagon R&D officials are concerned, failure to implement the submarines identification plan will not affect antisubmarine warfare electronic R&D. They say that it would only have utilized the same sort of equipment already under development in various antisubmarine-warfare programs.

Quality control rides the rails

Electronics concerns have long been used to demands for quality control from the aerospace industry and military users. They are starting to get used to such demands from the Commerce Dept. for its High Speed Ground Transportation Program. The agency has called attention to the need for precision signaling and reliable communications when several trains are operating at speeds to 150 mph on the same tack. Now, even the conventional railroading industry is calling for more electronics quality control.

The theme kept popping up at a recent Washington meeting of about 1,000 railway communications and signal officers. In addition to asking for tighter quality control, they also urged the electronics industry to come up with new equipment and modifications of older equipment. They want better freight-car numeral readers, better visual displays of the wide variety of information now being gathered and transmitted electronically, and improved hot-box detection and warning systems. The need for the electronic sensors and alarms to spot and warn of over-heated axle journal boxes was considered imperative.

NBS completes 10-MW nuclear reactor

The National Bureau of Standards has just finished assembling a U-235 fueled nuclear reactor that emits intense neutron beams.

Located at the new NBS facilities, Gaithersburg, Md., the reactor will provide the Bureau and the other laboratories near Washington, D. C., with an extensive neutron beam facility that can be used for fundamental research on crystal structure, intermolecular forces and chemical bond strengths.

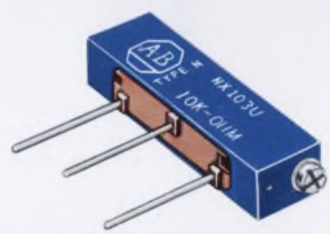
The NBS will use the reactor's high flux to study fission and neutron capture. Presently, an inadequate understanding of the fission process and lack of information on neutron yields limit the design of breeder reactors, according to a Bureau spokesman. The NBS also plans to use the reactor to generate radioisotopes for distribution as radioactivity standards.

ON READER-SERVICE CARD CIRCLE 20 ➤

Typical Philbrick solid state operational amplifiers. The Model P65A differential operational amplifier with cover removed shows the use of Allen-Bradley hot molded fixed resistors and an Allen-Bradley Type N adjustable fixed resistor for zero balance adjustment.

HOT MOLDED FIXED RESISTORS are available in all standard EIA and MIL-R-11 resistance values and tolerances, plus values above and below standard limits. Shown actual size.

The need for a yearly production capacity of well over a billion units is a testimonial to the uniformity and reliability of all Allen-Bradley hot molded resistors.



Type N hot molded adjustable fixed resistor rated 1/3 watt at 50°C ambient. Available with nominal resistance values from 100 ohms to 2.5 megohms with tolerances of ±10% and ±20%.

"Why have Allen-Bradley hot molded resistors been our first choice since the late 1940's? In a word: Reliability!" states Philbrick—the leading manufacturer of operational amplifiers. There's nothing accidental about this superiority of A-B resistors. A unique hot molding process using completely automatic machines, eliminates the "human element" and produces such uniformity from one resistor to the next—year in and year out—that long resistor performance can be accurately predicted. No instance of "catastrophic failures" has ever come to our attention.

Allen-Bradley Type N adjustable fixed resistors likewise use a solid hot molded resistance track. Adjustment is so smooth, it approaches infinite resolution—and settings remain fixed. Being noninductive, Type N controls can be used at high frequency, where wire-wound units would be completely unsatisfactory.

For more details on the full line of Allen-Bradley quality electronic components, please write for Publication 6024: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

63-05-6E

An Allen-Bradley announcement of importance to motor designers

The new MO6-C ferrite magnet having 30% higher intrinsic coercive force

The new Allen-Bradley MO6-C ceramic permanent magnets provide at least 30% increase in the highest previously available intrinsic coercive force—obtainable with A-B's MO5-C material. This advance is achieved with the same high residual flux density.

Designers of permanent magnet motors have a choice of these advantages—30% higher resistance to demagnetization, or 30% increase in motor output, or 30% increase in cold temperature protection. In fact, where the higher coercive force is not required, the designer can give himself a 30% reduction in magnet size.

This new Allen-Bradley MO6-C material opens the door to such motor designs where permanent magnets heretofore were not practical, namely for motors used in many portable tools and appliances. Like with the MO5-C material, these new MO6-C magnets are radially oriented, and are available in virtually all sizes and shapes currently being produced in segments for motors from ¾" diameter to 10 hp. While MO5-C magnets will continue to satisfy most needs, MO6-C enables designers to satisfy more exacting motor design requirements because of its unusually high intrinsic coercive force.

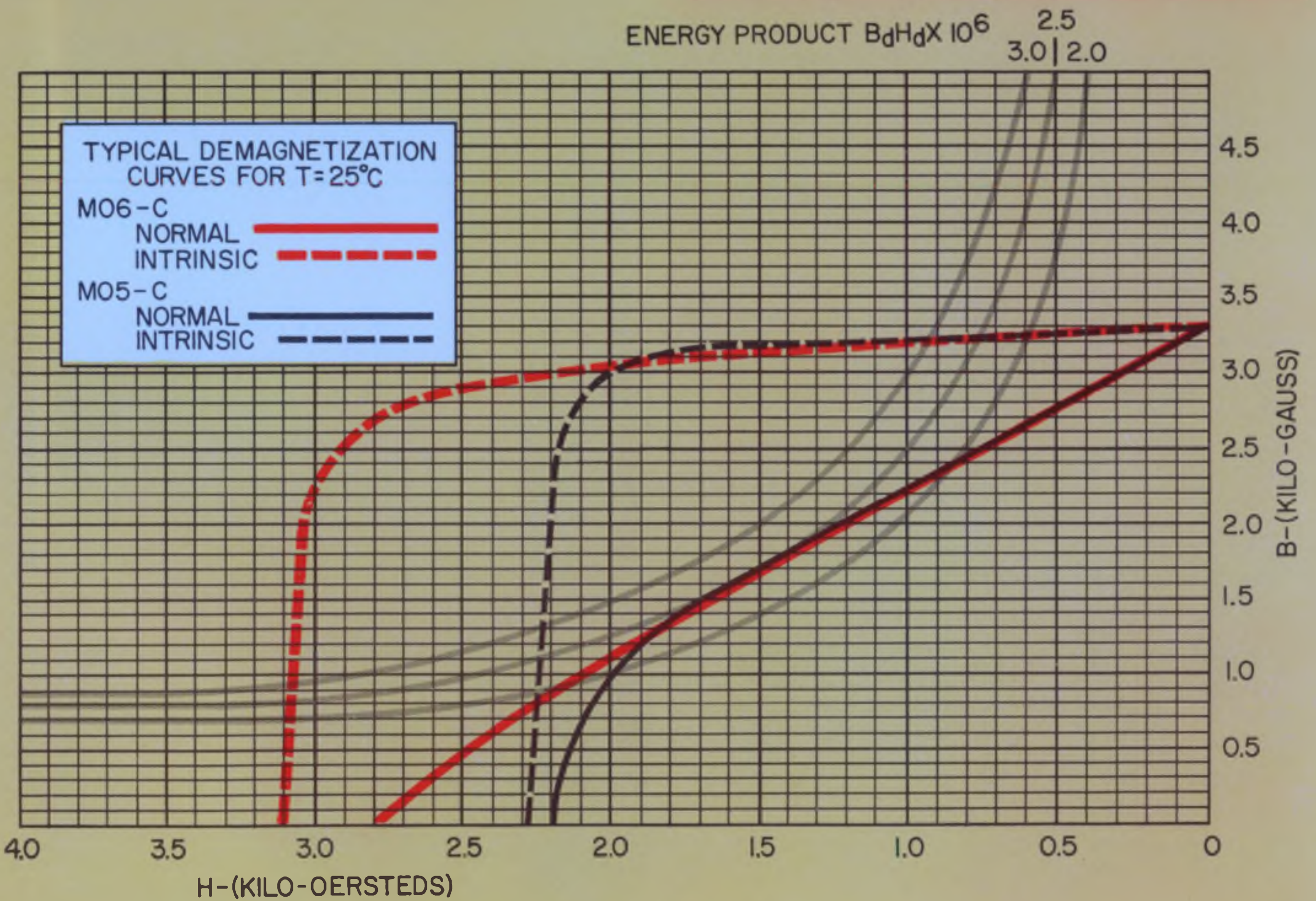
Allen-Bradley application engineers will be pleased to help you obtain maximum economy in your motor design through optimizing magnet performance. Please let us hear from you. Allen-Bradley Co., 222 West Greenfield Avenue, Milwaukee, Wisconsin 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

TYPE MO6-C CERAMIC PERMANENT MAGNETS

Typical Characteristics

–stated values have been determined at 25°C.

Property	Unit	Nominal Value
Residual Induction (B_r)	Gauss	3300
Coercive Force (H_c)	Oersteds	2800
Intrinsic Coercive Force (H_{ci})	Oersteds	3100
Peak Energy Product (B_dH_d max)	Gauss-Oersteds	2.5×10^6
Reversible Permeability	—	1.09
Curie Temperature	+°C	450
Temperature Coefficient of Flux Density at B_r	%/°C	−0.20
Specific Gravity	—	4.9
Weight per Cu. In.	Lbs.	0.177



ALLEN-BRADLEY

QUALITY MOTOR CONTROL

QUALITY ELECTRONIC COMPONENTS

64-05-6CE

Computers to read handwritten numbers

Non-technical people will now find it easier than ever to "converse" directly with a computer.

This view was expressed by G. B. Beitzel, president of IBM's Data Processing Div., as he introduced what he called the first machine that reads handwritten numbers directly into a computer for processing.

Designed for use with IBM's System/360, the 1287 optical reader can recognize numbers and five different hand-printed alphabetic characters, pencil-written, on a wide variety of business documents.

The 1287 also reads machine-printed and credit-card-imprinted numbers and feeds the information into the computer for processing.

Because the data are transmitted directly from source documents into the computer, Beitzel says, the process saves time and money and eliminates conversion errors.

IBM has solved the problem of identifying handwritten numbers by means of a tiny "flying spot" of light, about five one-thousandths of an inch in diameter.

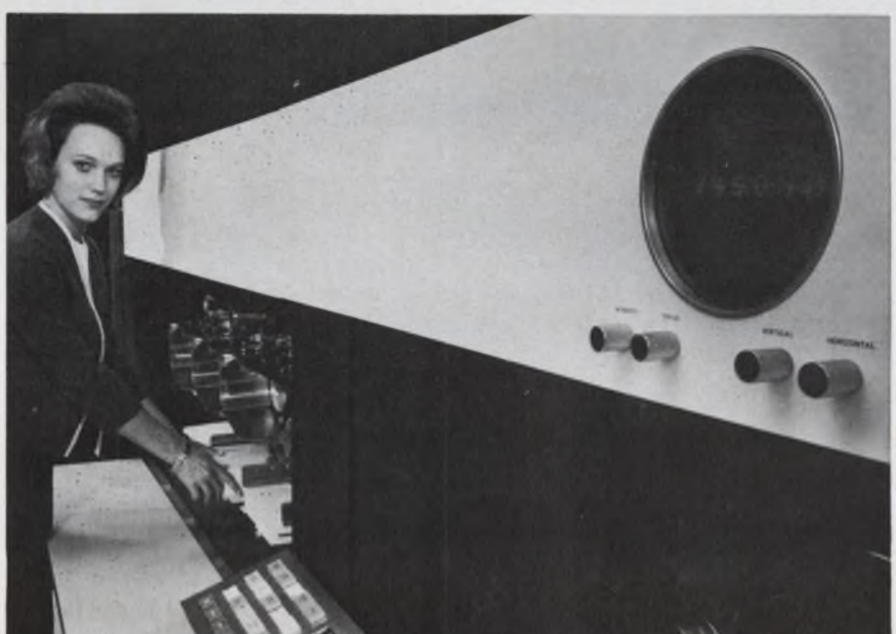
Projected by the 1287's sensing unit, the flying spot scans lines or fields of numbers on a document. When it crosses any part of a handwritten or printed number, it spirals (curve-follows) completely around the number before moving on.

Logic, built into the 1287, interprets the values of numbers traced by the flying spot and automatically transmits them to the System 360 for processing.

The five hand or machine-printed alphabetic characters—"C," "S," "T," "X" and "Z"—are read by the machine in the same manner. The five letters are used as information coding symbols on 1287 documents.

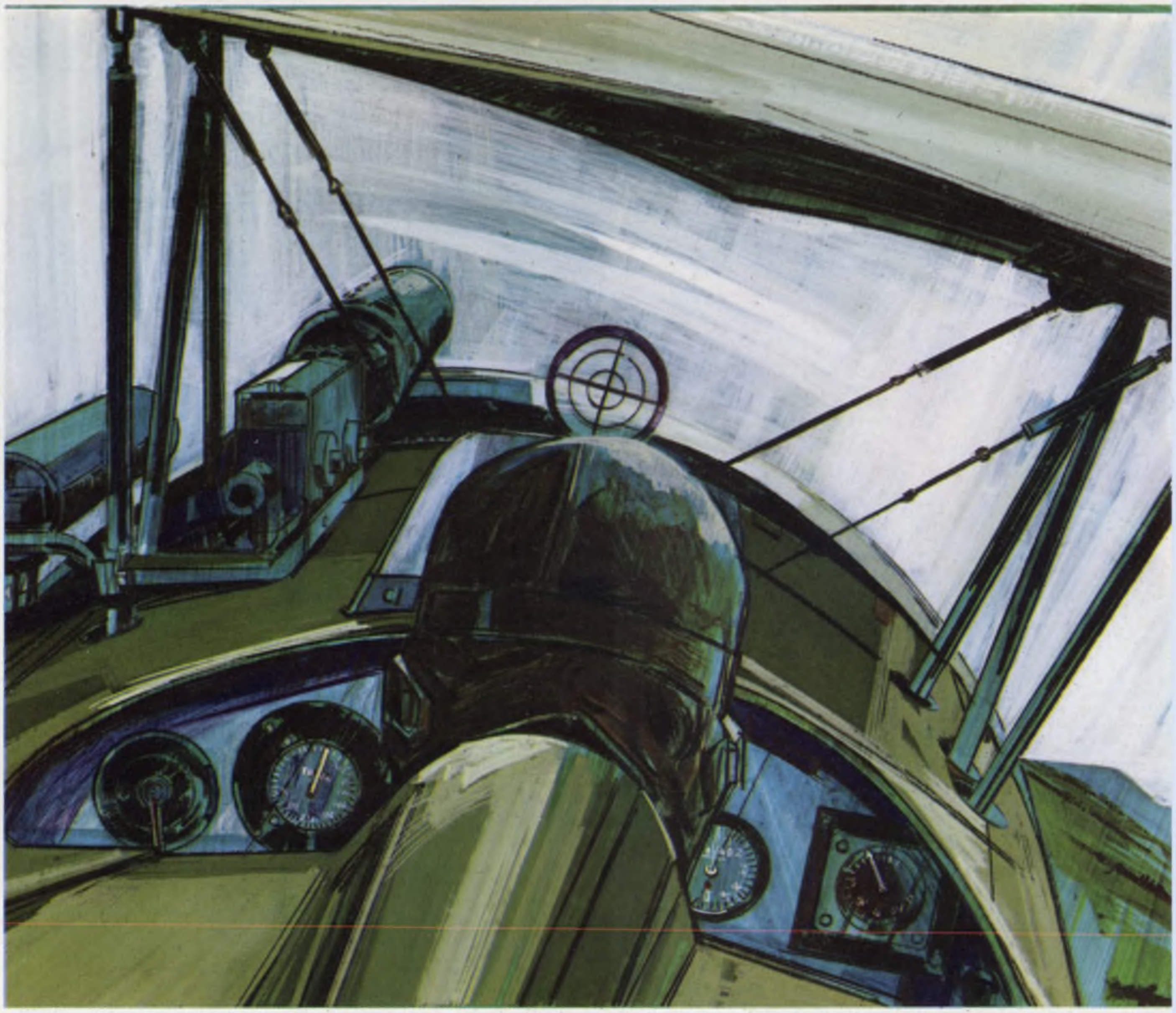
The flying spot scans and curve-follows machine-printed numbers at a rate of about 300 a second, Beitzel said. Document reading speeds vary, however, he said, depending on the size of the document, the amount of information to be read and the mix of written, printed, imprinted and pencil-marked numbers.

Multiline documents containing 30 to 40 handwritten numbers are read by the 1287 at a rate of about 125 a minute. ■ ■



Handwritten numbers can now be read directly into a computer by means of IBM's 1287 optical reader. Designed for use with the company's System/360, the machine can recognize numbers and five different hand-printed alphabetic characters pencil-written on a variety of business documents.

◀ ON READER-SERVICE CARD CIRCLE 20



The Kind of Knowledge that makes progress possible...

It was World War I. Man had already learned to fly, but he was an uneasy "bird" in flight. With the war came instrument flying. It gave man a new ability and confidence in the air, and galvanized his dream to conquer space. Now, in an age of electronic sophistication, man's dream beckons reality.

It took many minds of different skills to accomplish this dramatic progress in aviation. Mental perception of the highest order. Perseverance. Dedication in the face of setbacks. Step by step, a priceless knowledge of experience was stockpiled.

Accuracy increased in TWT inspection

An automatic production-control device has eliminated a major bug in traveling-wave tube production: helixes, or spiraled wires, that deviate from the specified pitch and impair the tubes' operation.

To insure production of uniform helixes, RCA's Industrial Tube and Semiconductor Division in Harrison, N. J., now checks the helix, turn-by-turn, before it is assembled in the TWTs. The automatic inspection device determines any deviation from the required pitch, with an accuracy greater than previously available units, an RCA spokesman said.

A key component in the system is a memory encoder. Called Mem-O-Tizer, it provides a fast and accurate readout that shows whether the pitch of the helix deviates from the prescribed norm, and by how much. Deviations as small as one micron can be detected.

Other components in the system include a microscope, preset controller and a moving stage containing a precision gear train and drive motor. Here is how the system operates:

The helix is formed by winding tungsten or molybdenum wire around a mandrel. Still on the mandrel, the helix is placed horizontally on the moving stage under a microscope. The first turn of the helix or wire spiral is manually focused under the microscope, and the required pitch between windings is dialed on the preset controller. When the controller is switched on, the remaining operations are performed automatically by the equipment.

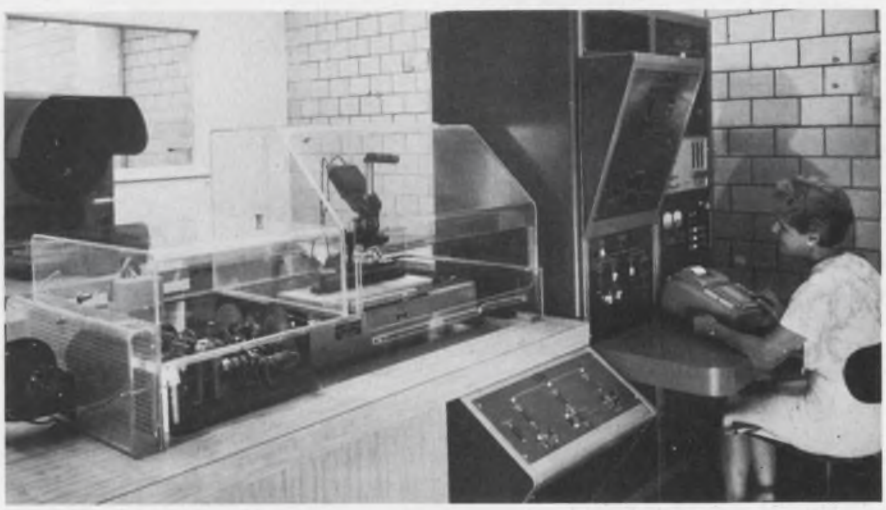
A drive motor moves the helix in increments of five microns, while a "scoreboard" on the system's control panel records the measurement of the pitch. When the mandrel has traversed the same number of microns dialed on the control panel, the drive motor shuts itself off. If the pitch is correct, the second turn of the helix should then be exactly centered in the optical system of the microscope.

If the second turn is centered, the operation is repeated for successive turns. If it is not centered, two photo-electric cells in the microscope cause the mandrel to move forward or backward until the second turn comes into sharp focus. This deviation is displayed on the control panel.

Each reading on the control panel is recorded by the operator to provide a permanent record. In case of future tube breakdowns, these records will provide a clue to the cause.

To insure controlled atmospheric conditions, the microscope, drive motor, precision gear train and Mem-O-Tizer are enclosed in a protective transparent plastic cabinet.

Previously RCA used a comparator to check pitch deviation. In that hand-operated system, the comparator inspects a helix in spans of 10 turns rather than turn-by-turn. ■ ■



Automatic traveling-wave tube inspection system checks for production errors. Developed by RCA the device measures the pitch of helixes.

They laughed when I sat down to play. . .

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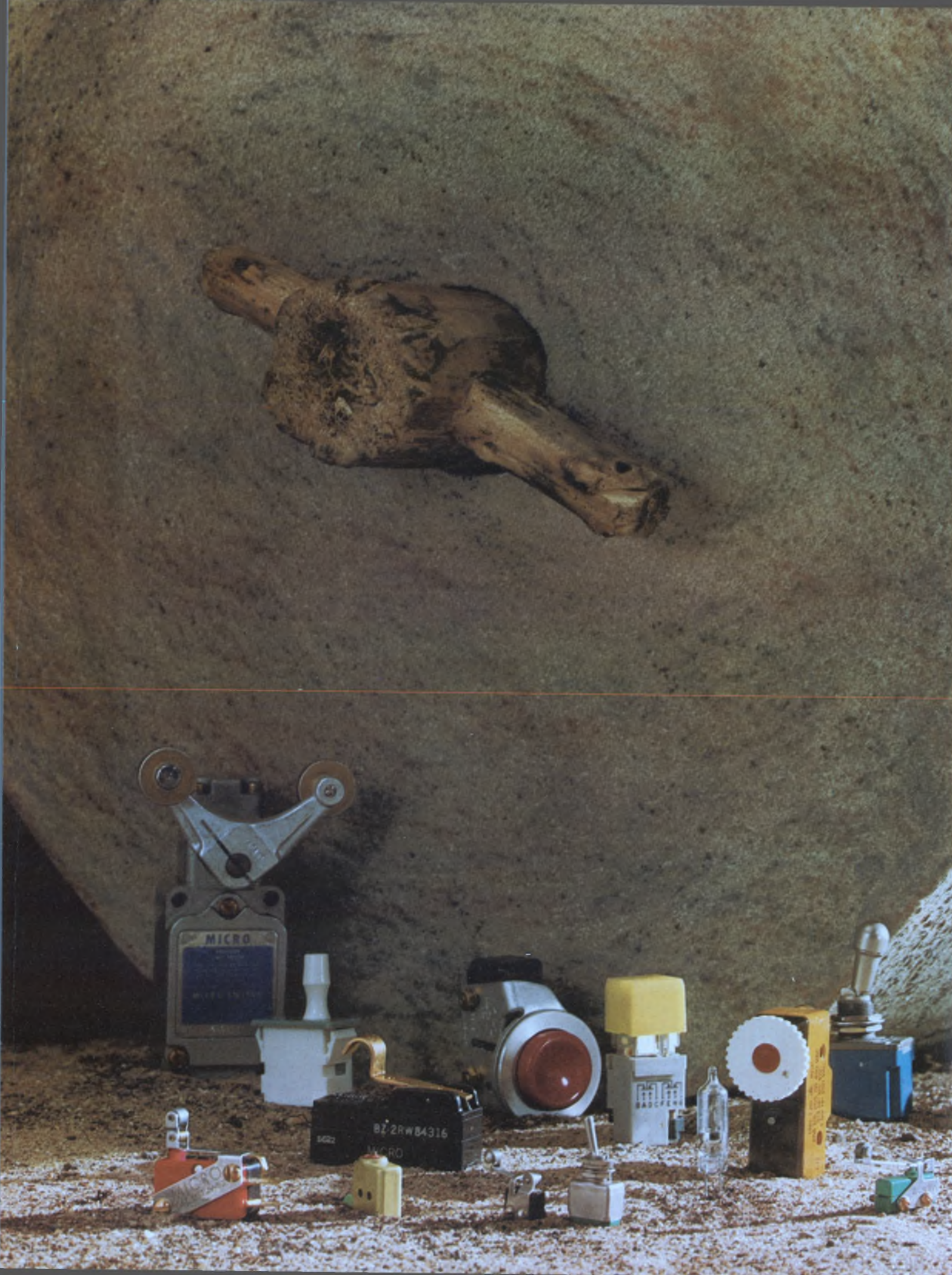
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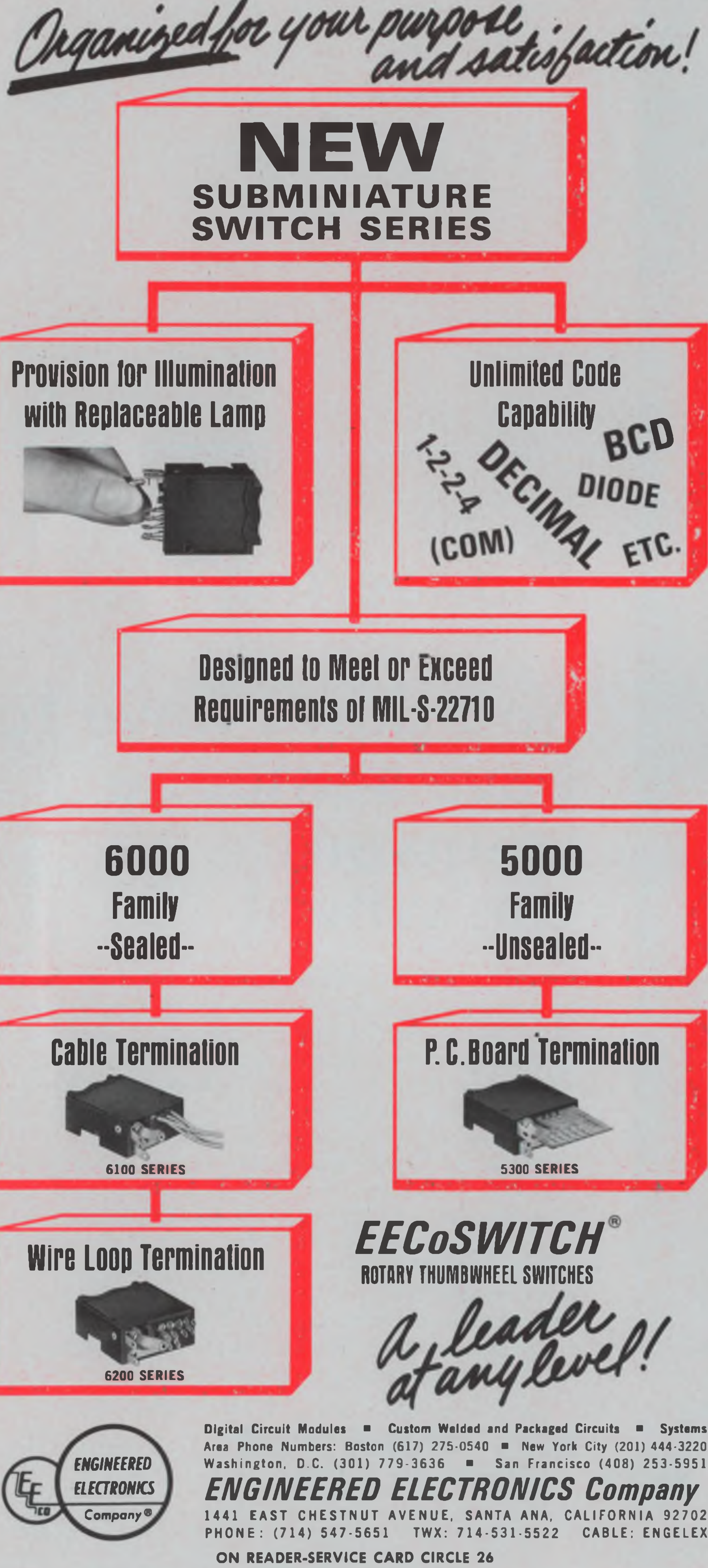


ON READER-SERVICE CARD CIRCLE 26

A 35-lb radar set destined for Vietnam

A battery-operated radar set, small enough to be carried about and operated by one man, may soon be used in Vietnam to detect moving enemy guerrillas or moving vehicles.

The 35-lb unit is less than one-seventh the weight of models now used in Vietnam, say officials of the Radio Receptor Div. of the General Radio Corp., Hicksville, N. Y., builder of the set.

The miniaturized device can be set up in less than five minutes and is so designed that a trained operator can distinguish between an individual, groups of men and vehicles by doppler frequencies associated with the distinct movements of each, the company says.

The radar set can detect a crawling target or a walking man at a range of 1500 meters, or a small moving vehicle at 3000 meters. A moving target is revealed by a distinctive tone in the operator's headset; the quality of the tone indicates the type of target detected.

A sighting telescope mounted on top of the unit is also available to aid in visual location of the detected target. The electronic system simultaneously gives range readouts from a counter and azimuth readouts from a graduated scale. The entire unit is mounted on a tripod and is said to be completely silent in operation.

General Radio said it would provide the new radar sets initially to the Naval Ships Systems Command for use by the Marine Corps. ■ ■

Portable radar in operation.

ON READER-SERVICE CARD CIRCLE 27 ➤

Boeing wants it that way. One Microstack provides permanent nondestructive memory for operating instructions and data words with a design reliability goal of 100,000 hours MTBF. The other provides a temporary memory for incoming and outgoing messages with a design reliability goal of 5,000,000 hours MTBF.

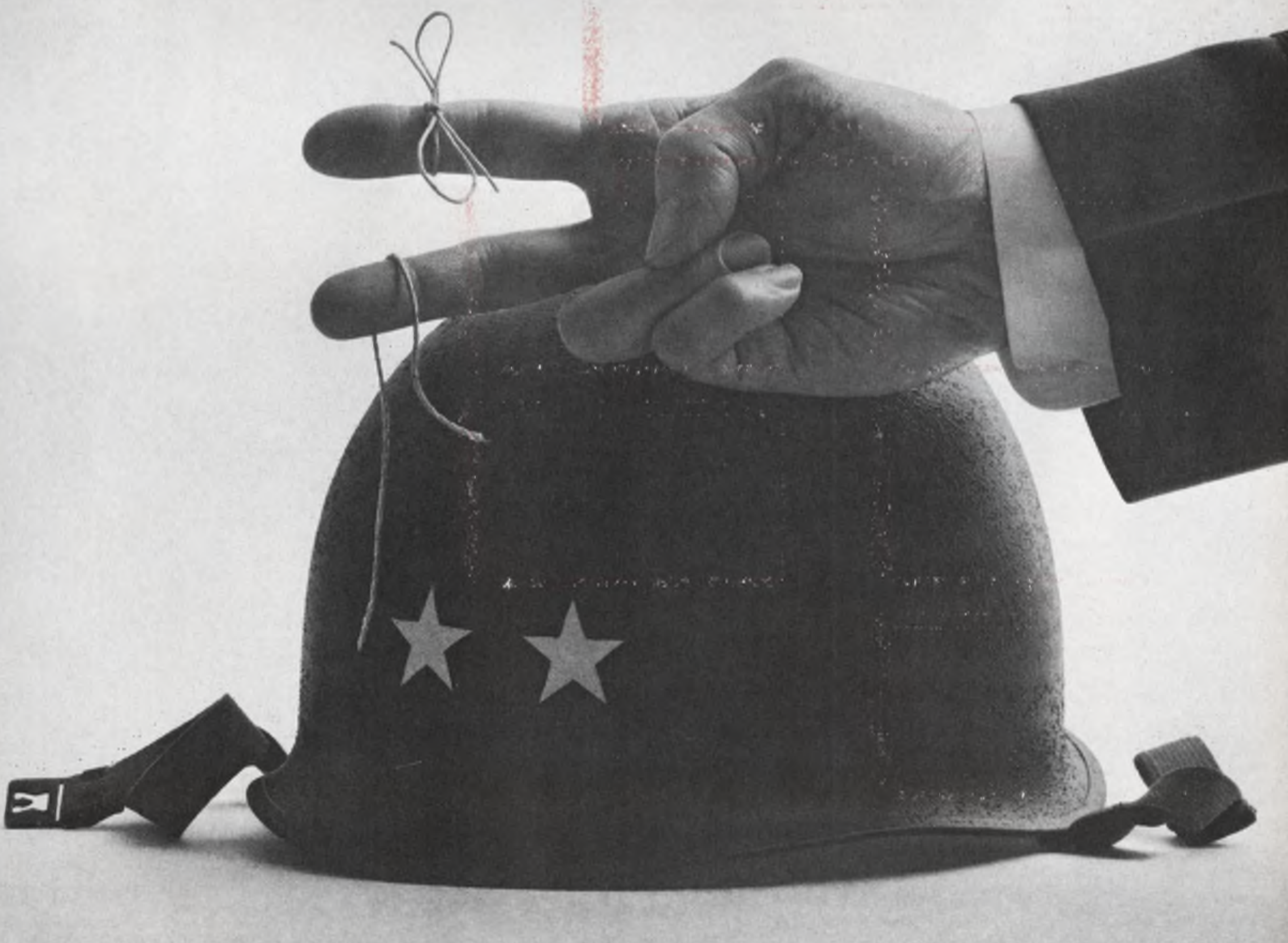
One of the reasons Boeing uses Microstacks is their unique design. A folded-array originated by Indiana General. The "X" and "Y" axis of all the memory planes are continuously wired. This reduces solder connections 80%, greatly increasing reliability as well as cutting size and weight. This folded-array is specially-packaged to meet Mil. Spec. temperature, humidity, shock and vibration, and extreme environment requirements.

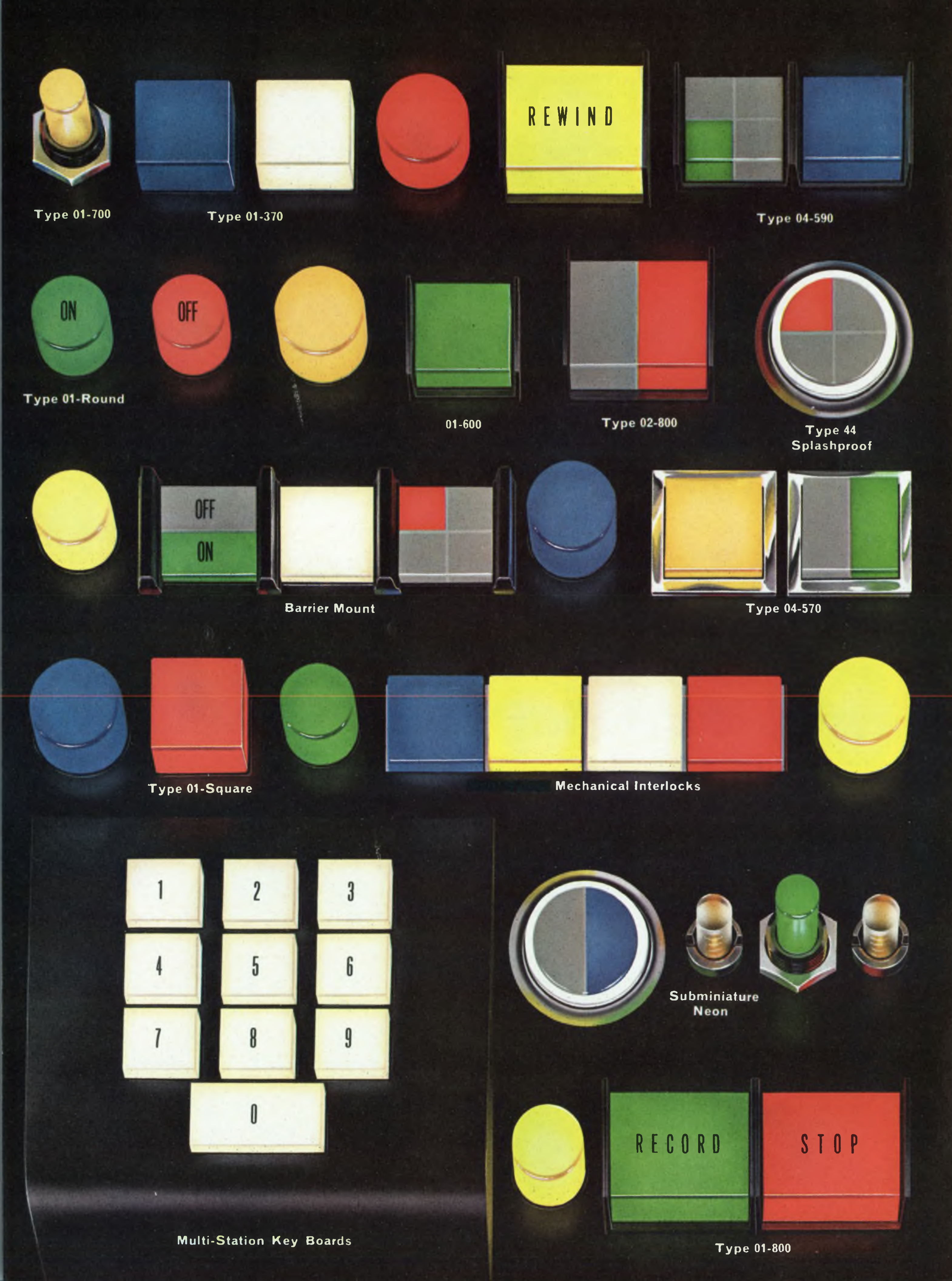
Another reason was our ability to develop cores to Boeing's specifications. We invented the ferrite memory core and make and sell more of them than anyone. Our facilities for developing and producing cores and stacks are second to none.

If you need Mil. Spec. type memory units find out about Microstacks and our core capabilities. Write Mr. Thomas Loucas, Manager of Sales, Indiana General Corporation, Electronics Division/ Memory Products, Keasbey, N. J.

INDIANA GENERAL

There are two Microstack® memory units in Minuteman II. One remembers. The other forgets.





Type 01-700

Type 01-370

Type 04-590

Type 01-Round

01-600

Type 02-800

Type 44
Splashproof

Barrier Mount

Type 04-570

Type 01-Square

Mechanical Interlocks

Subminiature
Neon

Multi-Station Key Boards

Type 01-800

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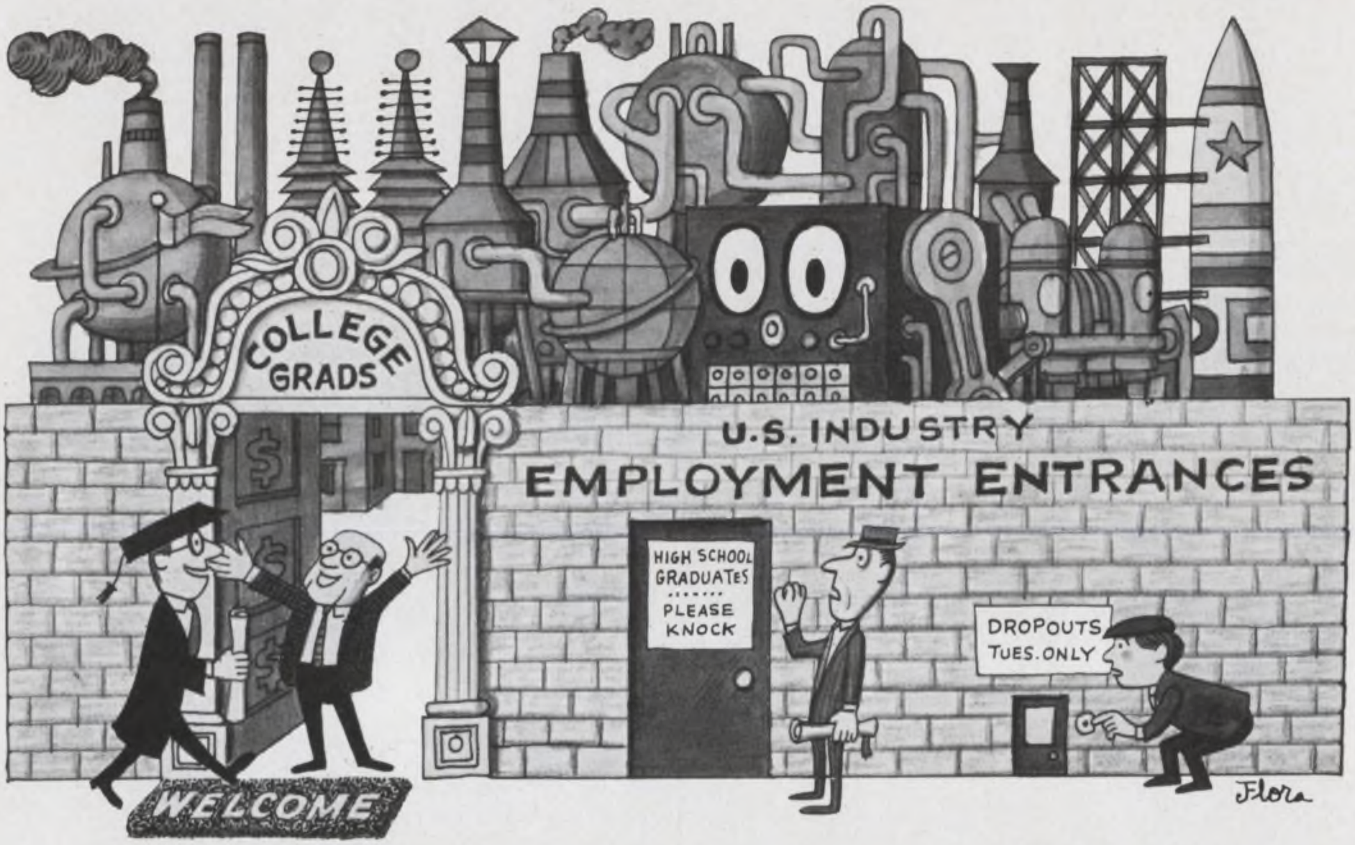
ON READER-SERVICE CARD CIRCLE 28



It takes a good education, to get a good job today

As a businessman, you know what it takes to get ahead in today's industry. But most young people don't.

Of all those who will enter the labor force by 1970, 7.5 million will not have completed high school. It's a big problem for our country. A real problem for our economy . . . and for industry, too.

What can you do about it?

Plenty! In your own community, make it *your* business to show how important a good education is in business today. Talk about it. Write about it. Urge your business and civic organizations to cooperate.

Convincing young people of the value of getting all the education and training they can is not only good for your community, it's good for your business, too. After all, the quality of your future employees depends a lot on their education. Even your present employees can benefit greatly by up-grading their skills through on-the-job training or night school.

For more information on how you can help solve the continuing education problem in your community, write: The Advertising Council, 25 West 45th Street, New York, New York 10036.

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Provide a minimum attenuation of 100 db over the frequency spectrum of 14 KHz to 10 GHz. Unmatched for performance in screen room and power line applications. Versatile mounting either with threaded fitting termination through shield room enclosures, or with universal conduit mounting. Rated 25 amps to 200 amps up to 250 VAC, 0 to 400 CPS.

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Designed for use in 600 ohm balanced lines or in 300 ohm individual lines. Removes spurious noise from audio source lines entering screen rooms or other shielded enclosures. Stocked in two configurations: for universal conduit mounting; or with threaded fitting terminations.

NF Rectangular Pi Filters

Designed to meet performance requirements of MIL-F-15733. High attenuation over the range of 150 KHz to 1 GHz. Stocked in 1, 5 and 10 amp ratings. Line frequency range from 0 to 400 cps up to 250 VAC or 600 VDC. For bulkhead mounting or chassis shielded flange mount.

NFR Tubular Pi Filters

Designed for high attenuation of RF interference over the ranges of 150 KHz to 10 GHz and 14 KHz to 10 GHz. Stocked in 1,5 and 10 amp ratings, up to 250 VAC or 600 VDC. Styles suitable for both prototype and production requirements. For bulkhead mounting.

STF Solid Tantalum Feed-Through

Type STF-2 (30 amps, 35 VDC) provides high attenuation from 14 KHz through 10 GHz. Sub-miniature device with 20:1 size reduction over comparable paper feed-through capacitors.

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NFT 15 Amp, 125C Feed-Through Filter

Available in 100 and 600 VDCW ratings. Capacitance ranges of .1, .22, .33, .47 and 1.0 Mfd.

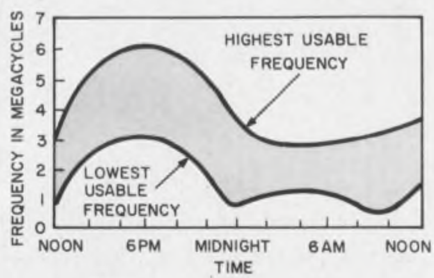
Automatic switching may solve RF noise

Automatic frequency selection may be developed for high-frequency communications some day, if engineers determine that this approach can reduce atmospheric disturbances of radio waves.

Sylvania's Electronic Systems Division has just set up two receiving/transmitting stations 400 miles apart to determine the effects of atmospheric changes on broadcasting. "Accurate measurements of these disturbances will assist us in the design of automated long-distance communications equipment," says Stuart Morrison, the division's director of engineering.

It has been known for many years that sunspots interfere with high-frequency radio waves. An automatic transmitter such as that visualized by Morrison would detect the onset of interference in one portion of the frequency spectrum and shift a broadcast to a channel in an unaffected portion. Also, a certain amount of historical information could be programed into the system. "Frequencies employed for daytime transmission differ from those used at night," says Morrison. "The best frequencies for communications also vary from month to month and from year to year, depending on sun spots."

"At present," he continued, "radio operators must monitor signals continuously to ensure that changing conditions in the ionosphere —several layers of electrically charged air between 50 and 400 miles above the earth—do not disrupt communications." ■ ■



Transmitted signals may reflect back and forth between the ionosphere and ground (like the 3.5-MHz signal above), but they might just continue out into space. The insert shows the nature of variations in the usable band during a typical day.

Letters

Henry not an unknown and here's proof

Sir:

Although he lives and works in Copenhagen, a city whose libraries are the envy of the less fortunate, Mogens Boman did not succeed in finding biographies of Joseph Henry and asks: "Henry? Who was he?" [ED 19, Aug. 16, 1966, pp. 54-56]. By the same token, a good case could be made out for the question: "Who was H. C. Oersted?"

With the help of one specialist librarian it took only a few minutes, at the Oslo Municipal Library, to get on the track of the following information.

Joseph Henry died on May 13, 1878. In January, 1879, the U.S. Congress ordered "Memorial Exercises" to be published in the *Congressional Record*. In addition, 15,000 copies of a "Memorial Volume" were printed: 7000 for the House of Representatives, 3000 for the Senate and 5000 for the Smithsonian Institution.

This 528-page book was published in 1881 as Vol. 21, No. 356, of the "Smithsonian Miscellaneous Collections," a series found in scientific libraries all over the world. Perhaps copies can be obtained even today. Presumably, this is the book of which Mr. Boman says: "The British Museum Library possesses the only copy." With very slight effort, six copies were found in Norway; one, from the Olso University Library, lies in front of me. The essential part of *Memorial of Joseph Henry* is the contribution by Prof. W. B. Taylor, "The Scientific Work of Joseph Henry," which, with "Supplementary Notes" and a chronological, 131-item "List of the Scientific Papers of Joseph Henry," occupies 221 pages.

In 1886, the Smithsonian Institution published, in two volumes, *The Scientific Writings of Joseph Henry*, totaling 1082 pages. This book, too, was very widely distributed.

In this manner, Joseph Henry's name was splendidly honored by his countrymen, shortly after his death, in a way which seems more than adequate to preserve his fame for all time. One wishes that other scientists could share his fate.

During the past 80 years many books have devoted chapters to Henry (e.g. MacLaren, 1943; Sharlin, 1963; etc.). The *Dictionary of American Biography*, 1946, has more than six columns. More recently, there appeared a 352-page biography (i.e., the second one on J. Henry), which must also have escaped the notice of the U.S. Embassy in Copenhagen: Thomas Coulson's *Joseph Henry, His Life and Work* (Princeton, N. J., 1950).

Gold, Mr. Boman, is where you find it.

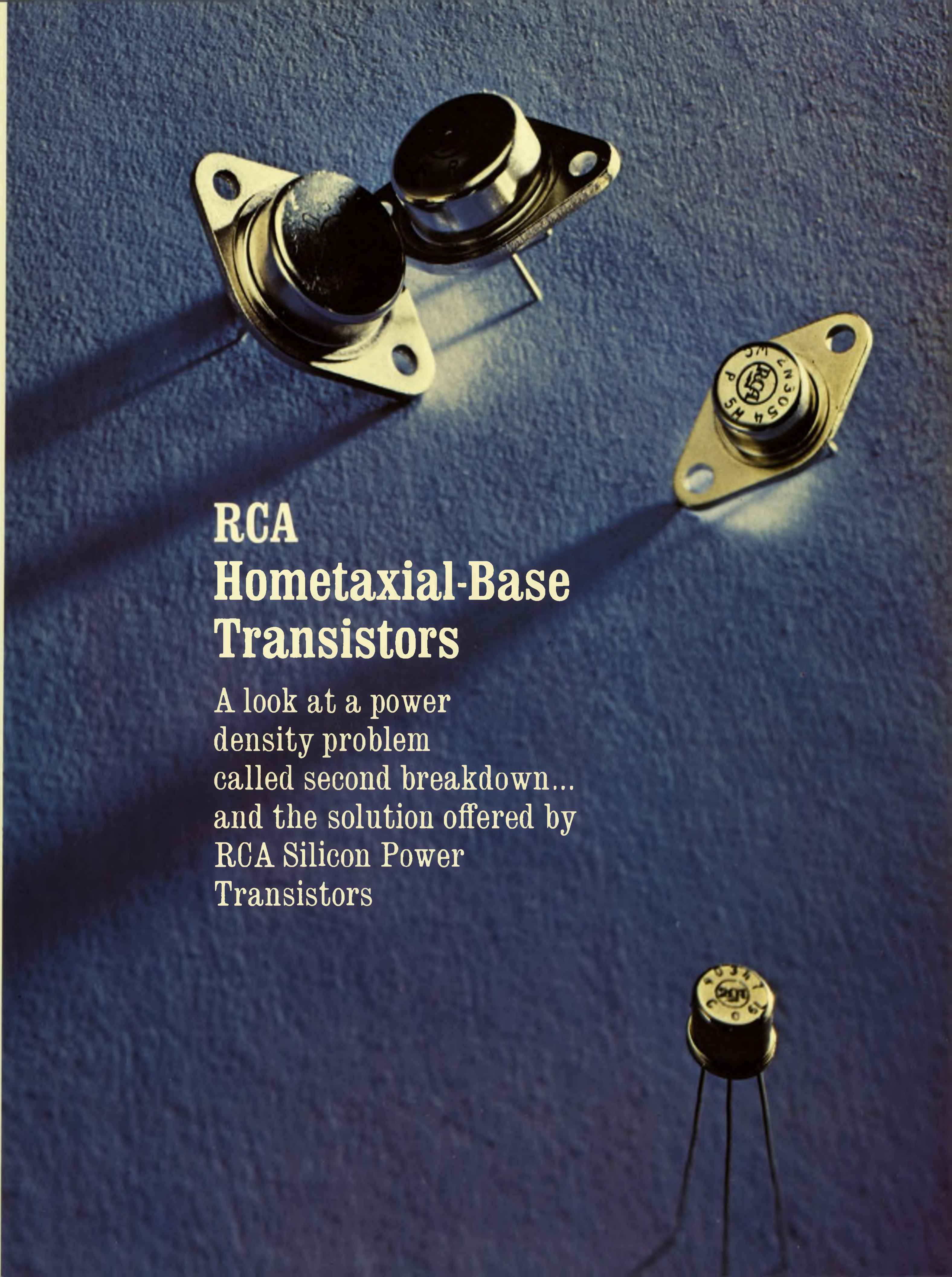
Kaye Weedon
Electrical Engineer
Blomenholm
Norway

Accuracy is our policy

In "Better isolation boosts IC performance," ED 21, Sept. 13, 1966, pp. 17-23, Radiation, Inc., of Melbourne, Fla., has drawn attention to a number of inaccuracies. Therefore, delete the top paragraph on p. 22 and substitute the following:

Warren Vergason, Radiation's manager of public information, says of the company's product line: "The dielectric isolation process has provided the industry with the highest-speed DTL digital gate family, the only monolithic diode matrices (see Fig. 3), and now the new, unconditionally stable operational amplifiers. The dielectric isolation process provides radiation-hardened circuits that withstand higher radiation dosages before degradation occurs."

In the second (middle) column on p. 21, all references should be to Figs. 2a through 2f, not to 3a through 3f as printed.



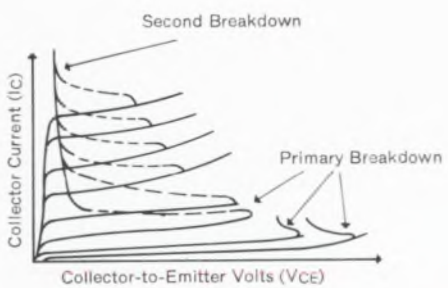
RCA Hometaxial-Base Transistors

A look at a power density problem called second breakdown... and the solution offered by RCA Silicon Power Transistors

PROBLEM:
Second Breakdown

WHAT IS SECOND BREAKDOWN?

Second breakdown is a potentially destructive phenomenon resulting from the formation of localized "hot spots" induced by high-current concentrations. It is so named because it is the secondary voltage breakdown as opposed to predicted or primary breakdown. Second breakdown is characterized by an abrupt collapse in V_{CE} with a simultaneous increase in I_C. The resulting combination of high current and voltage destroys the transistor unless adequate current-limiting techniques are used. While second breakdown can occur in all transistors, it is of particular significance in power devices where high currents and voltage are encountered.

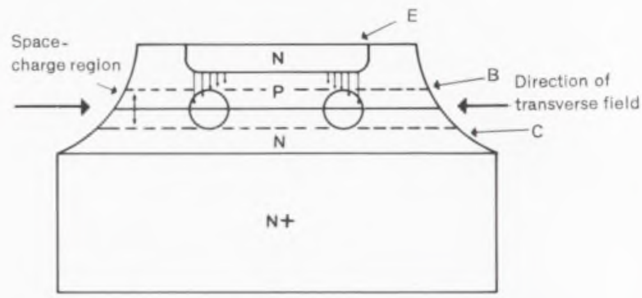


IN WHAT MODES OF CIRCUIT OPERATION IS SECOND BREAKDOWN ENCOUNTERED?

Second breakdown can occur in both forward- and reverse-bias modes of operation of the emitter-base junction. The operating principle differs in each mode, as does the amount of energy or voltage initiating the effect. Forward-bias second breakdown occurs most often in linear circuits using power transistors. Reverse-bias second breakdown usually occurs in inductive power-switching circuits.

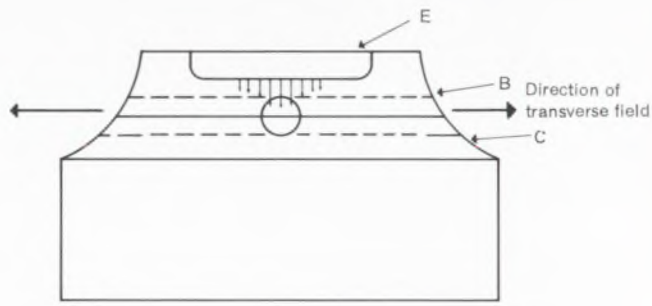
WHAT HAPPENS IN FORWARD-BIAS SECOND BREAKDOWN?

During forward-bias operation, a transverse electric field is set up in the base region, and a "space-charge" layer is formed at the base-collector-junction. As current flows from the emitter to the collector, the transverse field focuses the current flow into a narrow region under the emitter edge. When the current flows through the "space-charge" layer, a significant amount of heat is generated by the combined product of current and voltage. With current flow focused into a small area, the heating effect is localized and the formation of hot spots (circled areas in diagram) may result. If unchecked, these hot spots initiate a regeneration cycle of highly focused current which may destroy the transistor.



WHAT HAPPENS IN REVERSE-BIAS SECOND BREAKDOWN?

During reverse-bias operation of the emitter, the direction of the transverse field is reversed by the polarity change. As a result, the emitter current is focused into a small region at or near the center of the emitter. Because of the crowding of current flow into a region smaller than that under forward-bias conditions, reverse-bias second breakdown can be encountered at substantially lower power levels. The resistance of a transistor to reverse-bias second breakdown is reduced



by any design alteration which increases current density or prevents emitter current from fanning out. Power transistor designs which have (1) narrow base width, (2) an accelerating base field, or (3) insufficient emitter size for their operating current generally exhibit reverse-bias second breakdown at lower power levels than transistors without these factors.

WHAT IS THE RELATIONSHIP BETWEEN ENERGY REQUIRED FOR SECOND BREAKDOWN AND FREQUENCY CAPABILITY?

In the design of high-frequency transistors, the base width is minimized to reduce the transit time of emitter current through the device. The resulting short path does not permit significant current spreading or fan out. As a result, focused current flows across the collector junction with a resultant increase in power density and localized heating. Also, because of the narrower base region, this heating effect is more closely coupled to the emitter junction, promoting thermal regeneration and second breakdown. Designers should note that the selection of devices having higher frequency capability than needed for a given design greatly compromises circuit reliability and resistance to second breakdown.

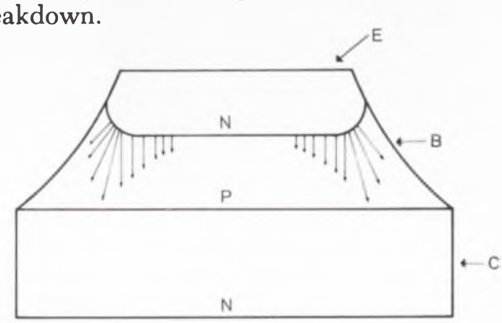
SOLUTION:
RCA Hometaxial-Base Transistors

WHAT IS RCA HOMETAXIAL-BASE TECHNOLOGY?

Hometaxial-Base technology is an RCA-developed process which has proved to be effective in preventing second breakdown. In this technology, a single-diffusion process is used to form both emitter and collector junctions in a uniformly doped silicon slice. The result is a *homogenously* doped base region free from accelerating fields in the *axial* (collector-to-emitter) direction—hence the name Hometaxial. The Hometaxial-Base transistor is also characterized by a wide base region, further enhancing the ability of the device to resist second breakdown. The attendant simplicity of this technology has resulted in a family of reliable, low-cost power transistors.

HOW DOES HOMETAXIAL-BASE TECHNOLOGY IMPROVE SECOND BREAKDOWN CHARACTERISTICS IN THE FORWARD-BIAS MODE?

Hometaxial-Base technology greatly minimizes the risk of second breakdown in the forward-bias mode by allowing the emitter current to fan out before it enters the collector region. Because uniform doping levels are employed, there is no field to accelerate the current. And because of the wide base width, the current fans out by electron diffusion before reaching the collector junction. Although these two factors limit somewhat the high-frequency performance of Hometaxial-Base transistors, they are most significant in preventing second breakdown.

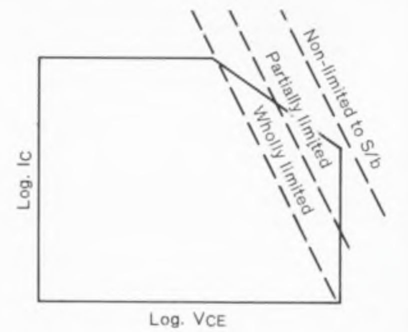


HOW DOES HOMETAXIAL-BASE TECHNOLOGY IMPROVE SECOND BREAKDOWN CHARACTERISTICS IN THE REVERSE-BIAS MODE?

Because of the high-current densities under reverse-bias conditions, wide base structure and uniform doping are even more important than in the forward-bias mode. In addition, the collector of the Hometaxial-Base unit is designed to prevent "localized widening" of the base region into the collector layer. This "localized widening" occurs in multiple-diffused designs when the emitter current density increases beyond a value consistent with the fixed impurity doping level of the collector. The collector region of Hometaxial-Base transistors is designed to minimize this widening and the degradation of breakdown voltage which accompanies it in multiple-diffused structures.

WHAT DEVICE RATINGS ARE AVAILABLE TO ASSURE MAXIMUM SAFE OPERATION IN THE FORWARD-BIAS MODE?

Every transistor is subject to second breakdown at some combination of voltage and current in the forward-bias mode. Accordingly, RCA has developed a series of "Safe Area of Operation" curves for both dc and pulse conditions. These curves show at what point a given transistor may be wholly limited, partially limited, or non-limited in terms of second breakdown. Such curves are now included in all recently published data for RCA Hometaxial-Base devices and are being added to the earlier published data sheets.



ARE COMPARABLE DESIGN CURVES AVAILABLE TO ASSURE MAXIMUM SAFE OPERATION IN THE REVERSE-BIAS MODE?

Specifying devices for maximum safe operation in the reverse-bias mode is somewhat more complex than for forward-bias conditions. As a result, RCA supplies a series of three curves which relate source voltage, source resistance, and output inductance to the power required for second breakdown. With such a rating system, the designer can determine whether circuit operation conditions fall within the safe-operating region indicated. Again, RCA is adding such design curves to its new data sheets and is revising existing sheets to include them.

SUMMARY

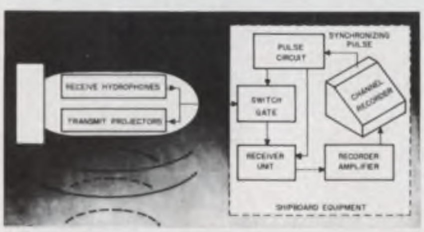
RCA's family of low-cost Hometaxial-Base transistors offers the user of silicon power devices two distinct benefits. First, it provides him with a proved transistor structure which, because of its wide-base, uniform doping, and special collector design, is inherently superior in eliminating second breakdown. Second, it provides him with a complete system of ratings curves which specify maximum safe operation in both forward- and reverse-bias modes. This combination of device design and application assistance equips the designer with a unique solution to the problem of second breakdown.

In "5-capacitor flat pack," in the Products Section of ED 18, Aug. 2, 1966, p. 95, the Erie Technological Products' flat packs are shown priced at $1.50 (1 to 49) and $0.98 (250 to 499). The company has corrected the price to $5.00 each in lots of 1000.

In "Fluidics: a simple pipeline to rugged control," ED 20, Aug. 30, 1966, pp. 17-21, the caption under Fig. 6 on p. 21 should read: "Any control cancels all outputs" (not, "Each control cancels opposite output," as printed).

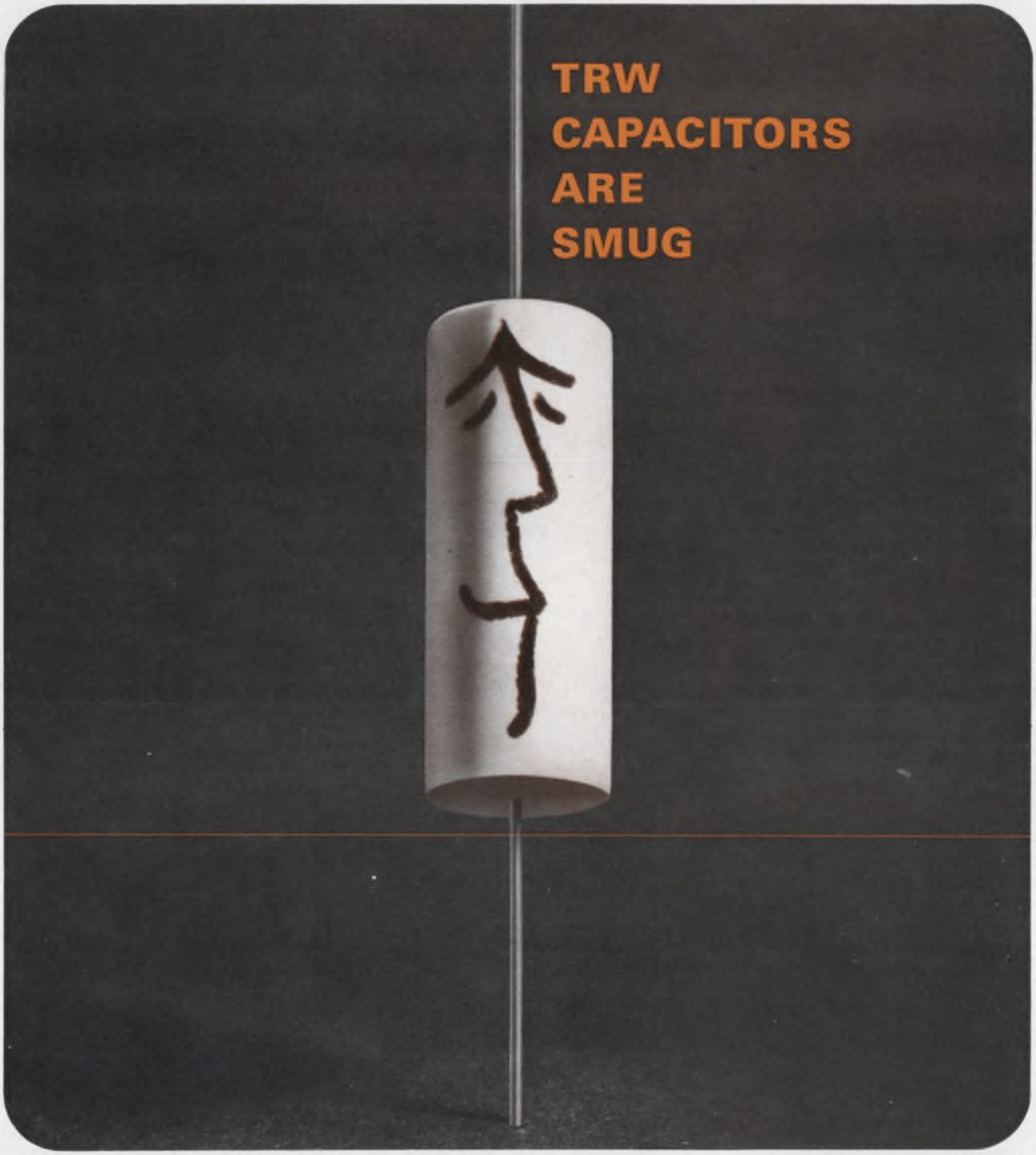
In "Sonar looks askance at sea bottom," ED 22, Sept. 27, 1966, pp. 17-21, the captions under the illustration on p. 21 and under the middle of the three pictures on p. 18 were wrong. The two pictures are republished below together with their correct captions.

Westinghouse version of SLS fish is prepared for launch. Main frame of the unit is 6-in. steel I-beam. Transducer cases (black stripe) are along the beam sides, the electronic package is above, the batteries are below.



Arrangement of transducer fish and shipboard elements of basic side-looking sonar equipment.

The caption that was printed under the middle illustration on p. 18 rightfully applied to a picture that we did not publish.



14-61

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TRW has now extended its leadership in film capacitors to include metallized polycarbonate types. Two features of the X463UW are outstanding. Precise processing assures low TC through temperature ranges to 125° C. Metallized construction reduces size to less than one half that of film-foil designs. Other features of the line include:

- Capacity range from .01 to 10.0 mfd
- Low dielectric absorption
- Available in tolerances to ± 1%
- Humidity resistance per MIL-C-27287

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TRW CAPACITORS

ON READER-SERVICE CARD CIRCLE 36

EDITORIAL

It's time we took the plunge in oceanology

Many industrial and academic leaders are standing on the shore of oceanology, drawn by the rich promise of research and development under the seas, but uncertain about plunging in. The prospects are virtually unlimited; yet at present their realization appears remote because of a lack of a unified approach. The organizations participating are divided into special-interest disciplines and factions. There is no strong movement for a unified attack on the problems of ocean exploitation, as there is in space. And up to now the likelihood of a big increase in government spending to support ocean science has been dim.

This picture may change in the near future because of legislation recently approved by Congress. The Senate and House have passed bills to grant funds to qualified colleges for education and research in the marine sciences along the lines of a proposal first advanced by Senator Clairborne Pell (D-R.I.). The bills—called sea-grant college bills—are now in joint committee to iron out minor differences between them. What should emerge is a version that will spread among ocean institutes and departments a fixed sum every year, starting with about $10 million. Final passage by both houses and presidential enactment seem assured.

This will at least establish a broad academic base for all future oceanographic efforts. Engineers, scientists and educators can be brought together to consider the social as well as the technical problems of marine exploitation. The guarantee of funds from the Government will encourage long-range applied engineering and science research projects without the need for specifying immediate goals. Electronics engineering, whose place is already well established in oceanological studies, would gain as much from this broad approach as other engineering disciplines.

But what are the benefits to industry? From a co-ordinated academic approach, scientists and engineers will emerge knowledgeable about many of the secrets of the ocean. This cadre will be prepared to plan the methods and design the tools for a greater assault on the riches of the sea.

The prospects for goods and services to support this effort are huge—underwater communications, vehicles, shelters and exploration equipment, to mention but a few. And there is the prospect that the yield from the sea may cover the costs, an incentive less likely from space exploration.

One area that holds great promise, for example, is fishing. Our present methods are as primitive as the cavemen's search for food with a bow and arrow. Why not sea ranches, with schools of fish rounded up like cattle?

The sea-grant college measure is a giant step toward preparing ourselves intellectually and technically for the conquest of what has been called "inner space."

NEIL SCLATER

If you have a good old frequency counter around, here's how to make it new again. Use our VLF Receiver to maintain your house standard and our Distribution Amplifier to conveniently place precise time base frequencies. Now, achieve an accuracy 1000 times better than when it was new.

The Fluke/Montronics Model 203 Distribution Amplifier provides an economical means of distributing precision frequencies from the standards laboratory to many different locations. There's no need to tie up your standards lab calibration equipment around the clock. And you'll never have to make time base oscillator adjustments or buy a counter with a crystal.

Used with a precision oscillator and a Fluke/Montronics VLF Receiver, all frequency dependent test equipment can be operated to an accuracy of 2 or 3 parts in 10^{11}. Pertinent specifications include: Inputs—Individual preamplifiers with level adjustment for 100 kc, 1 mc, and 5 mc, 0.5 to 5.0 vrms into 50 ohms; Outputs—12 separate outputs may be any combination of 3 input frequencies, 4 to 5 vrms into 50 ohms; Stability—Better than 1×10^{-11} standard deviation for one-second interval at 1 mc; Harmonics—At least 60 db below signal level; Spurious—At least 80 db below signal level; Power requirements—115/230 volts ±10%, 50-440 cps, approximately 35 watts; Price—$1,395.

For details and a demonstration call your Fluke/Montronics representative or write.

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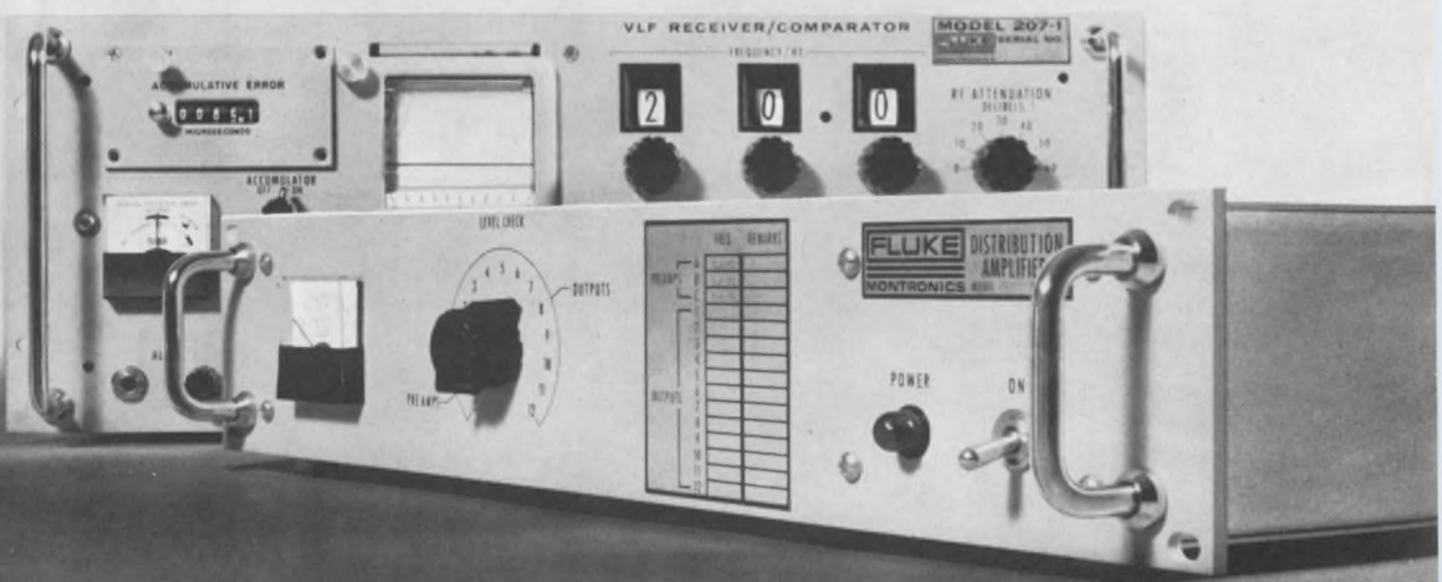
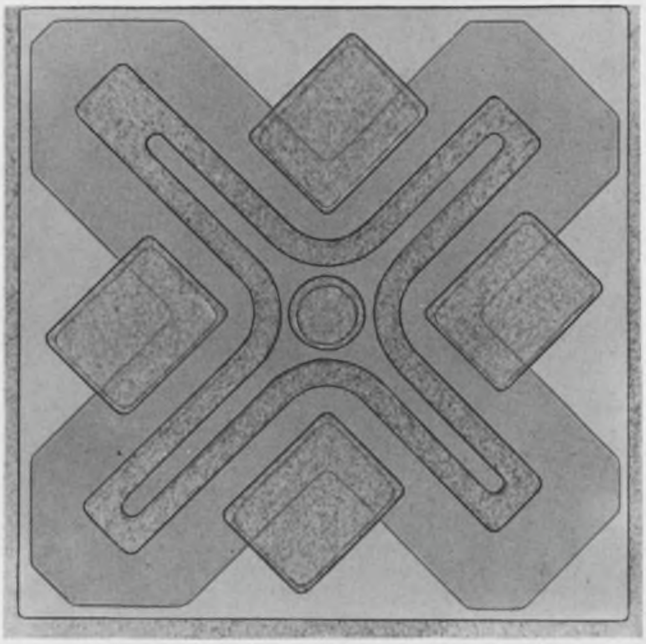
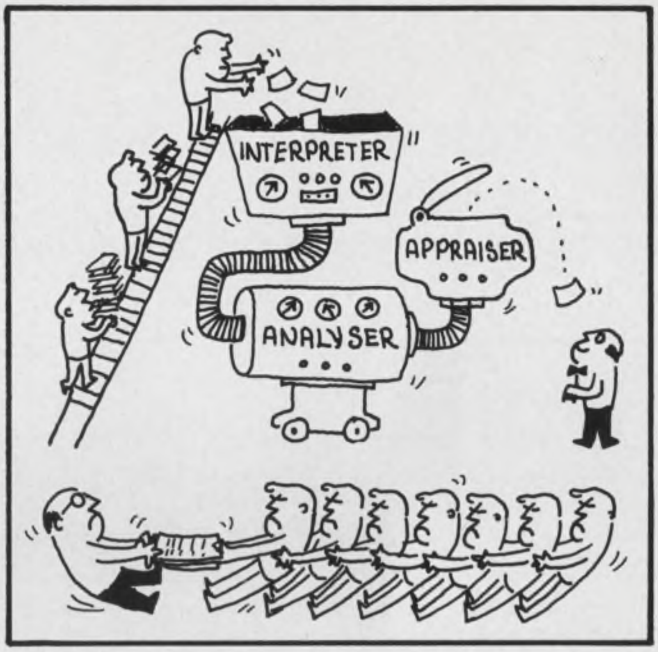


Model 203 Distribution Amplifier shown with
Model 207-1 VLF Receiver/Comparator

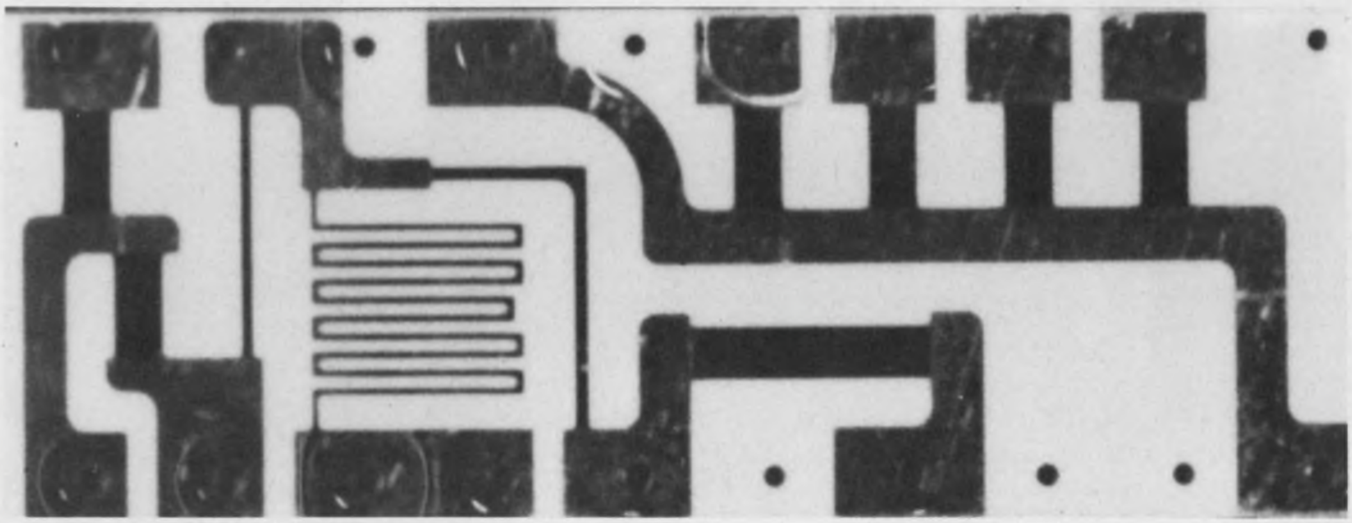
Technology



FETs designed for switching functions excel when employed for digital circuitry. Page 54



Wise delegation of work is the key to success for the manager of a project group. Page 88



Predict thin-film circuits' hot-spot temperature with a set of curves that help to reduce circuit size and simplify design. Results surpass those of constant ratings. Page 64

Also in this section:

Use a comprehensive checklist to select the right modules for your computer design. Page 72

Estimate the boresight error before getting a radome for your radar. Page 84

Ideas for Design. Pages 98 to 104

Switch over to field-effects for digital needs. Both the J-FET and the MOS-FET offer high fan-out, temperature stability and low component count in these applications.

Part 1 of a two-part article

Field-effect devices specifically designed for switching functions can play a valuable part in digital circuitry. Both the junction (J-FET) and metal-oxide-semiconductor (MOS-FET) types offer design and performance advantages not found in other semiconductors.

Although FETs will not eclipse either bipolar transistors or integrated circuits in logic applications, they do offer unique switching properties. Among the primary benefits characteristic of FET switching networks are:

- High fan-out capabilities.
- Direct-coupled circuitry and lower component count.
- Low temperature-coefficient behavior.
- Extremely low power dissipations.

The fan-out superiority is due to the high Z_{in} property of all FETs; coupling ease is a result of the capacitive input of MOS-FETs; thermal and power advantages arise when complementary FETs are used. By examining the properties of J-FETs and MOS-FETs as basic switching elements, the designer will come to understand how to apply them to meet digital circuit needs. Moreover, this study will reveal the essential differences between the field-effect and bipolar approaches to logic design. It will also sharpen his ability to choose between them when he has to.

Inverter is basic building block

The primary building block of digital subsystems is the inverter circuit. A common inverter circuit configuration using an n-channel J-FET is shown in Fig. 1. This simple circuit will serve to illustrate important FET characteristics in this application.

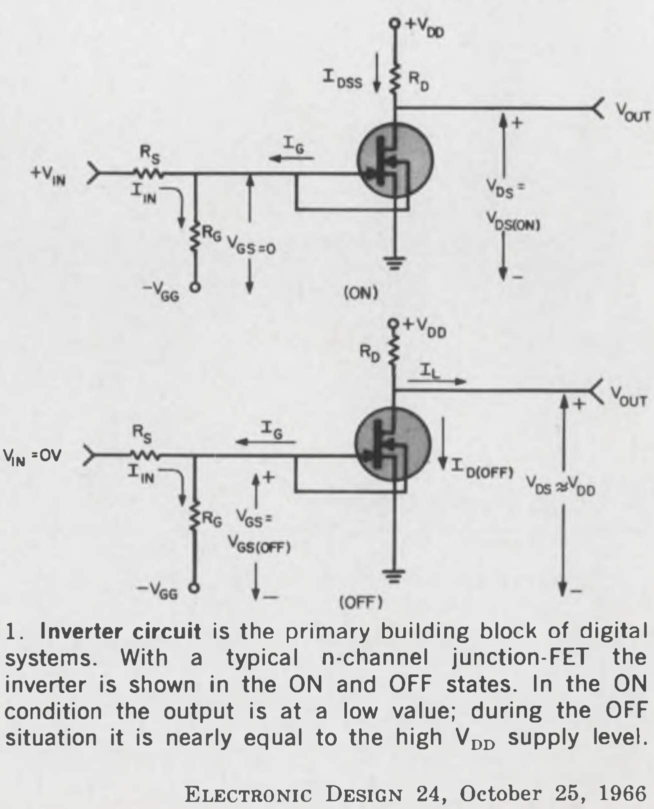
James Kane, Applications Engineer, Motorola Semiconductor Products Inc., Phoenix, Ariz.

A reverse voltage is provided by V_{GG} to hold the J-FET OFF, while a positive voltage at the input drives the device ON. Both the ON and OFF states of the inverter appear in the diagram.

With the input voltage at a positive level ($+V_{IN}$), the voltage divider circuit (R_S and R_G) is designed to bring the common gates of the J-FET to near ground potential. The J-FET when $V_{GS} = 0$ is ON, conducts a drain current of I_{DSS}. In the ON condition, the output voltage is at a low value, called $V_{DS(ON)}$.

The input circuit design must account for a current, I_G, coming from the J-FET. I_G is the junction leakage current of the gates; typically, it is a few nanoamperes or less. With the 3N126 as a representative device, $I_G = 0.25$ nA at 25°C.

In the OFF condition, the input is grounded,



1. **Inverter circuit** is the primary building block of digital systems. With a typical n-channel junction-FET the inverter is shown in the ON and OFF states. In the ON condition the output is at a low value; during the OFF situation it is nearly equal to the high V_{DD} supply level.

and the gates are reverse-biased to $V_{GS(OFF)}$. This is a voltage that reduces I_D to approximately 0.001 I_{DSS}. Again, a nanoampere leakage current of I_G appears in the input circuit. The output voltage is now at $+V_{DD}$ volts with only a small leakage current (0.001 I_{DSS}) flowing through the J-FET.

In view of these ON-OFF conditions, the pertinent static characteristics of J-FETs that are necessary for adequate switching design are:

- I_{DSS}—Drain-to-source current (at $V_{GS}=0$).
- $V_{DS(ON)}$—Drain-to-source ON voltage.
- I_G—Gate leakage current.
- $V_{GS(OFF)}$—Gate-to-source OFF bias voltage.

The information about I_{DSS} that is of interest is its magnitude and its behavior with temperature and drain voltage. For a junction FET, I_{DSS} is related to the device geometry and the resistivity of the channel. In the low-current region (when $V_{GS}=0$), V_{DS} is linearly related to the drain current. As V_{DS} is increased, the slope of the I_D-V_{DS} curve decreases because of channel depletion. When V_{DS} reaches pinch-off voltage, V_P, I_{DSS} saturates and is no longer sensitive to further increases in V_{DS}. The basic curve of I_{DSS} vs V_{DS} and temperature is displayed in Fig. 2.

High temperature reduces current level

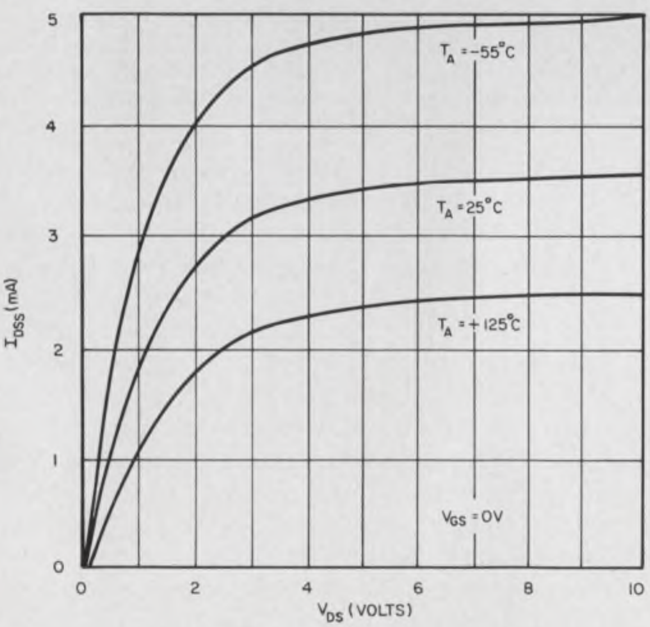
As the plot shows, I_{DSS} decreases as the temperature is increased. The slope of the characteristic in the low-voltage region (where I_{DSS} is linearly related to V_{DS}) is a measure of the channel resistance. As can be seen from the graph, the channel resistance increases with rising temperature.

Figure 3 shows the $V_{DS(ON)}$ characteristics of the 3N126 for various drain currents. These curves are used for designing the ON condition of the inverter. The resulting output voltage when the FET is ON can be determined from Fig. 3. Normally, the output of the inverter circuit is used as a logic level; consequently, there is a restriction on the allowable value of $V_{DS(ON)}$. For a specified limit for $V_{DS(ON)}$ then, a minimum value of V_{GS} can be chosen from the plot.

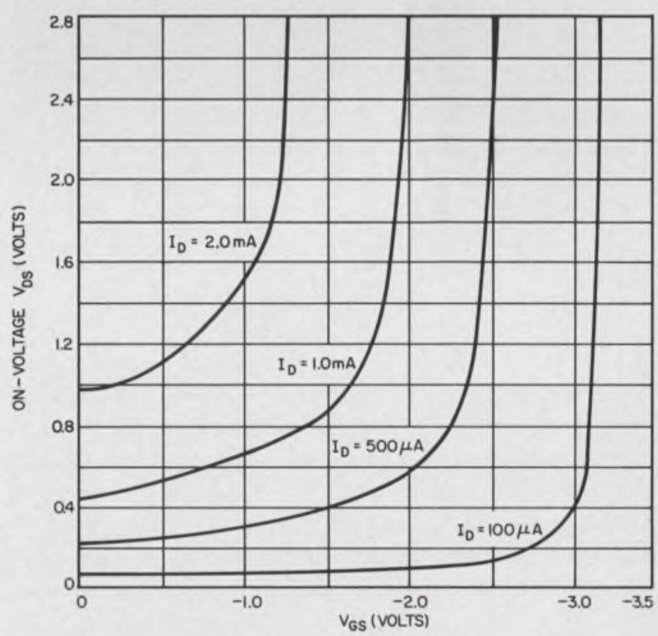
Practical problems normally faced in designing the inverter circuit (see Fig. 1) are the tolerance factors of the resistors, the input voltage and V_{GG}. The J-FET is usually restricted to use with reverse bias only. A practical design that considers tolerance factors results in a nominal V_{GS} that is somewhat less than zero volts. As Fig. 3 shows, slight changes in V_{GS} when $I_D=2$ mA changes $V_{DS(ON)}$ drastically.

On the other hand, if the circuit is designed for a drain current of 0.5 mA and a nominal V_{GS} of -0.5 volts, output voltage V_{DS} does not vary appreciably for variations of gate voltage up to ± 0.5 volts. Thus by utilizing this portion of the device characteristics, circuits with quite good component tolerance and noise immunity can be designed.

In the OFF condition, I_{GSS} and $V_{GS(OFF)}$ are the critical FET parameters affecting circuit design. Figure 4a exhibits I_{GSS} vs temperature for the 3N126 and indicates the expected junction leakage-current curve. Parameter $V_{GS(OFF)}$ (Fig. 4b) increases with temperature; consequently, when calculating the input circuit of the inverter, the highest expected temperature should be considered. Doing this will provide an adequate value of



2. **Drain-to-source current** (I_{DSS}) of a J-FET (at $V_{GS}=0$) is a function of drain voltage (V_{DS}) and ambient temperature (T_A). When V_{DS} reaches a "pinch-off" value, I_{DSS} saturates and becomes insensitive to further V_{DS} increase.



3. **The ON-state inverter** behavior is determined from a plot of drain voltage (V_{DS}) vs gate voltage (V_{GS}) as a function of drain current (I_D). V_{DS} here refers to a heavily conducting condition for the J-FET. For a given $V_{DS(ON)}$, the minimum value of V_{GS} may be found.

$V_{GS(OFF)}$ over the expected temperature range. This wraps up the static FET conditions—the inverter circuit design is now complete.

The switching (dynamic) characteristics of the FET inverter circuit can now be examined. Figure 5 shows the equivalent model of the J-FET inverter. The J-FET is represented by a gate capacitance, C_{gs}, to ground, a feedback capacitance, C_{gd}, and, a resistor, r_{ds}, representing the channel resistance. This last parameter is a function of V_{GS}.

Gate-source capacitance C_{gs} can be calculated from the measured values of C_{iss} and C_{rss}. C_{iss} is the parallel combination of C_{gd} and C_{gs}; C_{rss} is by definition equal to C_{gd}. Thus, C_{gs} is simply the difference between C_{iss} and C_{rss}, measured at the same voltage. The behavior of C_{iss}, C_{gd} and r_{ds}, with bias, are the dynamic characteristics of the J-FET that affect switching times. C_{iss} and C_{rss} are simply junction capacitances—they follow well-predicted voltage relationships. Factor r_{ds}, however, holds the key to the switching performance since it is related to gate voltage V_{GS}.

Switching times function of r_{ds}, C values

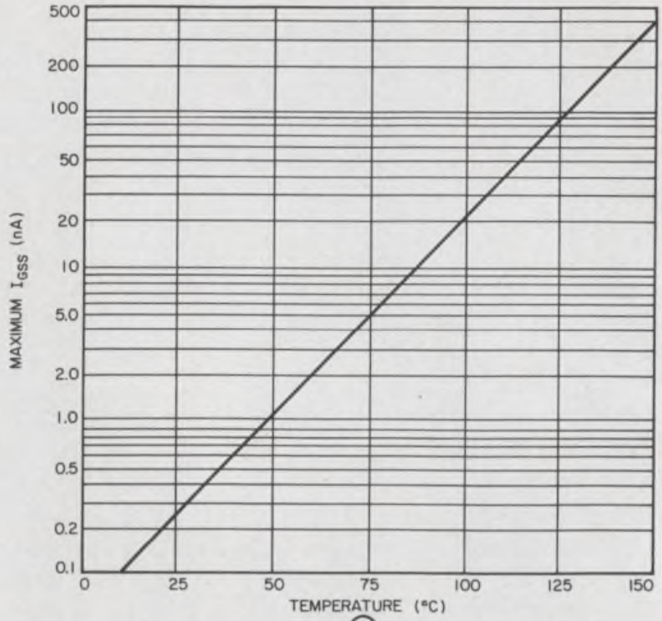
Consider the switching behavior of the J-FET inverter of Fig. 5. At the beginning of the turn-on switching interval, C_{gs} is charged to $-V_{GS(OFF)}$, C_{gd} is charged to $[V_{DD}+V_{GS(OFF)}]$ and load capacitance C_L is charged to $+V_{DD}$. Assuming V_{IN} is a step of voltage from a generator of zero impedance, the input network can be "Theveninized" as a resistor R_T equal to the parallel combination of R_K and R_G. The discharge time of C_{gs} is governed by this resistor, according to a time constant equal to $R_T C_{gs}$.

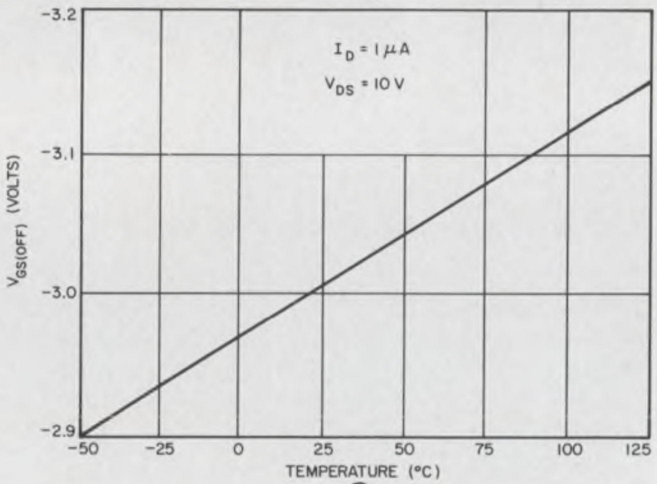
In operation, C_{gd} discharges through R_T and the parallel combination of R_D and channel resistance r_{ds}. During the turn-on interval, r_{ds} is decreasing; hence, at the start of the turn-on interval, R_D predominates. At the end of this interval r_{ds} is the performance-determining resistor. In effect then, the discharge time constant of C_{gd} is nonlinear. The time constant for C_{gd} is given approximately by:

$$\tau_{gd} \approx C_{gs}[R_T + R_D r_{ds}/(R_D + r_{ds})], \qquad (1)$$

where r_{ds} is a function of V_{gs}. Figure 6b displays the nonlinear relationship of r_{ds} that affects the switching time. Figure 7 shows the actual switching times of the 3N126 as a function of drain current. For these curves, R_K and R_G were changed (along with R_D) for each value of drain current. The parallel combination of R_K and R_G was always set equal to R_D to simulate a practical switching situation where the inverter would be driven from a similar inverter with a drain resistance equal to R_D.

Consider first the turn-on delay time t_{d1}. An examination of this curve shows that t_{d1} decreases



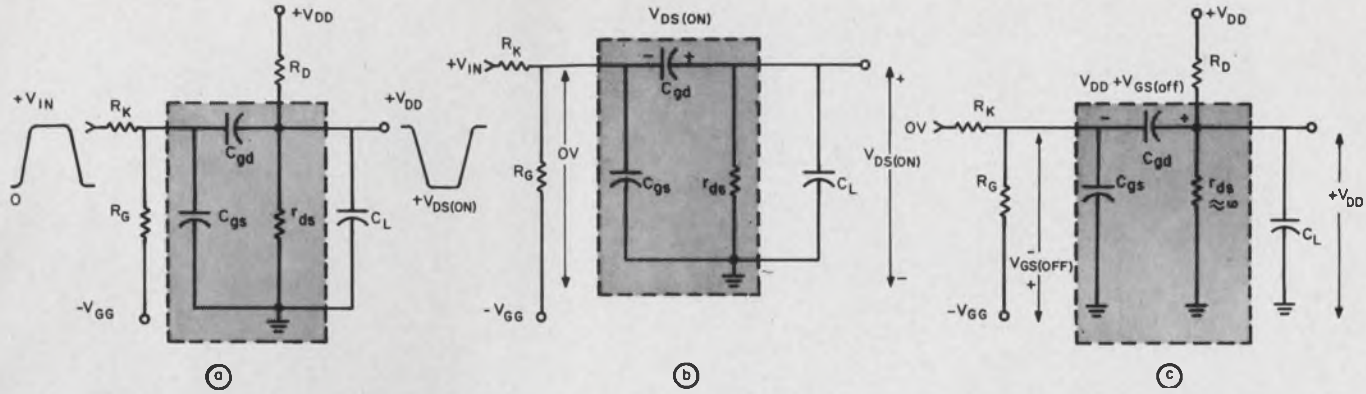


4. **The key OFF-state parameters** in the J-FET inverter are (a) the gate leakage current (I_{GSS}) and the (b) gate-to-source bias voltage for non-conduction ($V_{GS(OFF)}$). Both factors are dependent upon ambient temperature.

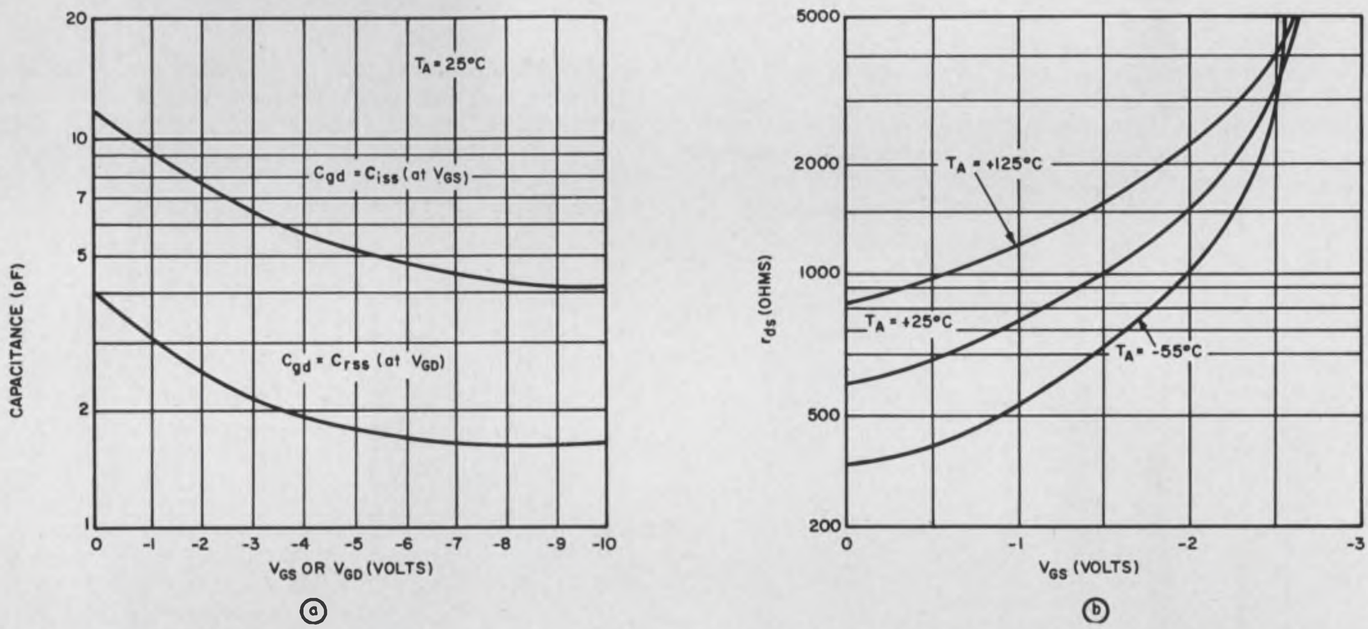
in direct relation to I_D. This is because t_{d1} is solely determined by the combination of R_T and R_D as long as the channel has not yet turned ON. Both of these resistors are varied in direct relation to I_D, and thus t_{d1} also becomes directly related to I_D. If I_D is doubled, t_{d1} is reduced by a factor of 2.

This same behavior is noted on the rise-time (t_r) curve. Owing to the relatively large gate time constant, $R_T C_{gs}$, for this particular device, the channel resistance does not affect the turn-on time until near the end of the interval. In effect, the rise time simply reflects changes in the external resistors and is directly related to I_D.

The turn-off time of a J-FET is quite different from that of a bipolar junction-transistor. First, the turn-off delay time of a J-FET is not a storage-time phenomenon, it is simply a part of the charge time of C_{rss} and C_L. Secondly, the turn-off time is a function of the input time constant as



5. **Equivalent circuit of J-FET** inverter (see Fig. 1) is used to determine the dynamic behavior. Here (a) C_{gs} is the gate capacitance to ground, C_{gd} the device's feedback capacitance and r_{ds} the channel resistance. Changing voltage levels for the OFF state (b) and ON state (c) demonstrate the FET switching action.



6. **Capacitance and resistance parameters** of the J-FET affect switching times. Factors C_{iss} and C_{rss} are voltage-dependent junction capacitances (a). Channel resistance r_{ds} is a function of both voltage and temperature (b).

well as the feedback and load capacitance.

Compared to the turn-on delay time of the J-FET, the curve of turn-off delay time, t_{d2}, has a steeper slope as drain current is increased. During the turn-off delay time, the channel resistance is increasing. For a standard measurement of delay time, i.e., to the 90% point, r_{ds} has risen to 1/10 of R_D at the conclusion of the delay time.

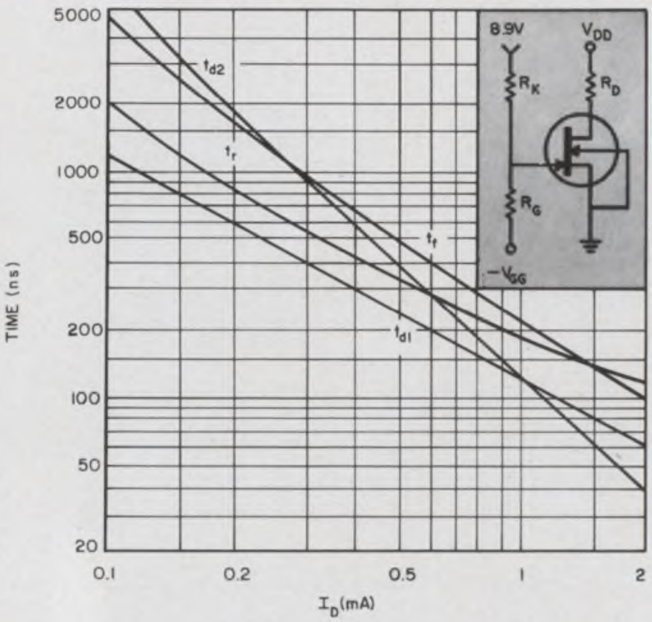
For the test circuit, when I_D is 2 mA, R_D is calculated to be 5 kΩ. In Fig. 6b, V_{GS} does not change very much from zero volts to bring r_{ds} to 1/10 of R_D—500 ohms. At low currents, however, the required change in V_{GS} is greater. For example, when $I_D = 0.2$ mA, R_D is 50 kΩ. Again with reference to Fig. 6b, it takes about −2.7 volts to bring r_{ds} to 5 kΩ. Therefore, at low currents V_{GS} must change by a large amount during the delay time in comparison with the small voltage change required at higher currents.

One additional fact tends to make the turn-off time longer than the turn-on time. In Fig. 6a, both C_{iss} and C_{rss} are at their largest when the bias is zero. This condition is nearly met with the device ON. When the device is OFF, both capacitors are reverse-biased, resulting in a much lower capacitance during turn-on.

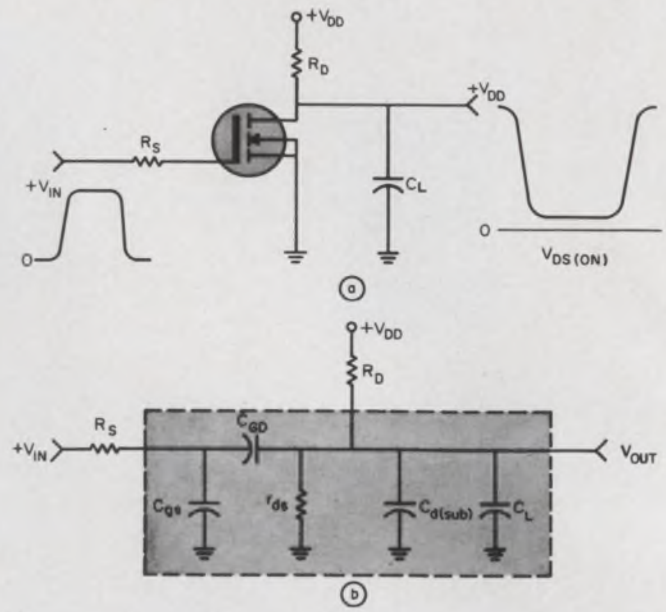
MOS-FET has lower leakage current

The MOS-FET is a 4-terminal semiconductor, as opposed to the 3-element junction-FET.

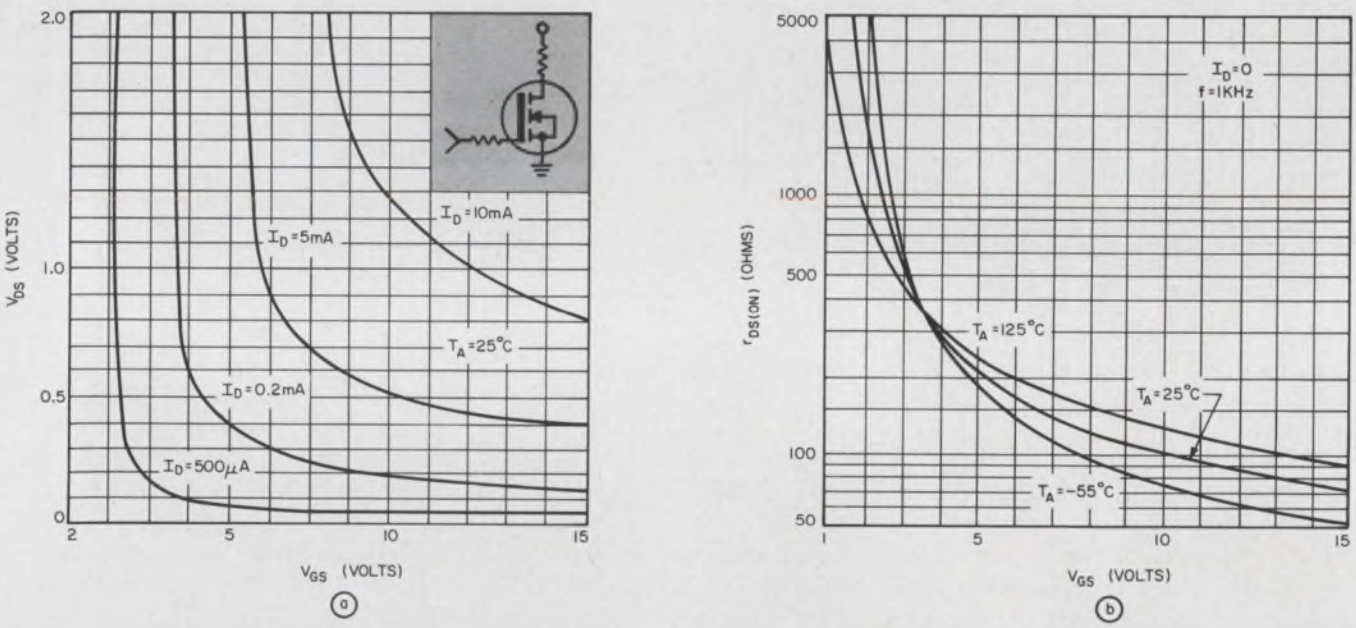
The characteristics of the MOS-FET which affect digital circuit design can also be examined by looking at the basic inverter circuit (Fig. 8). Note that the MOS-FET equivalent circuit is the same as the J-FET circuit, except for the drain-substrate capacitance, $C_{d(sub)}$. Despite this similarity, however, the switching characteristics of the two



7. **Switching time** for the J-FET inverter (see Figs. 1 and 5) is a function of drain current. For the circuit representation shown in the insert, $V_{DD} = 10$ V, $V_{GG} = -20$ V and $V_{GS(OFF)} = -5$ V. Also, t_{d1} is the turn-on delay time, t_r the rise time, t_f the fall time and t_{d2} the turn-off delay time. The parallel combination of R_K and R_G is equal to R_D.



8. **MOS-FET inverter** (a) and its equivalent circuit (b) are used to analyze MOS digital switches. Comparison of circuits with J-FET inverters (see Figs. 1 and 5) reveals that a drain-to-substrate capacitance must be considered here. Also, gate leakage of MOS-FETs is lower than that of J-FETS and an OFF bias supply is not needed.

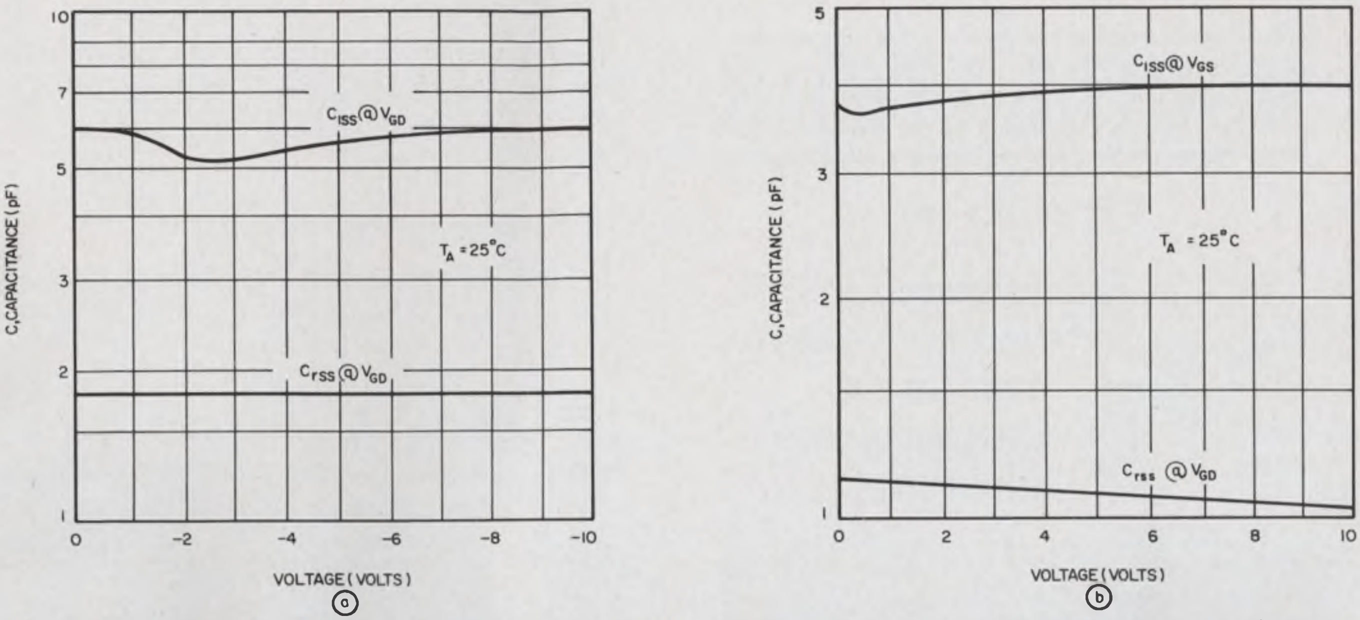


9. **A key static characteristic** of MOS-FET inverters is $V_{DS(ON)}$. Its variation with V_{GS} and as a function of drain current I_D (a) is useful for designing the ON (saturation) state of the inverter. ON resistance ($r_{ds(ON)}$) is another switching parameter (b). It is less influenced by temperature than its J-FET counterpart, channel resistance.

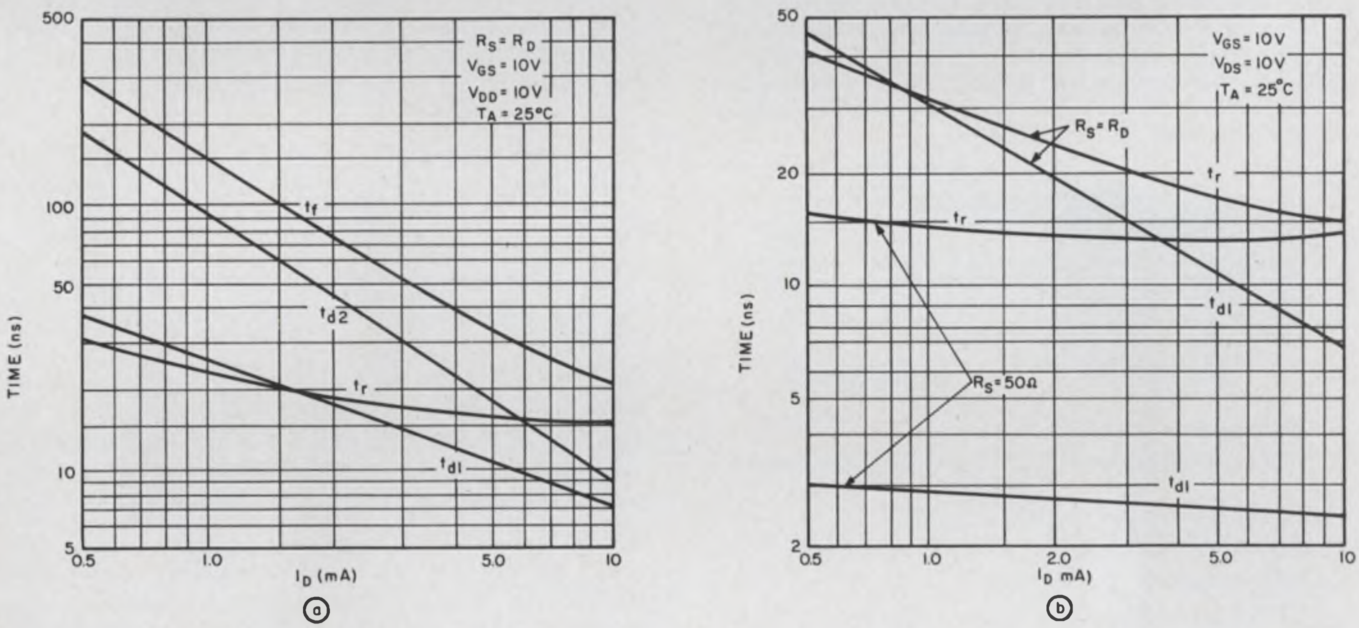
circuits are quite different.

The MOS-FET inverter does not require an OFF bias supply as did the J-FET circuit. The input is represented simply as a source resistance, R_S, and an ideal pulse generator. With the input at zero, the MOS-FET is OFF. Drain current I_{DSS} here is typically lower than in the case of J-FETs. If the 2N4351 device is taken as a representative MOS-FET, the maximum value of I_{DSS} is 10 nA in the OFF state. The output is at the high logic-level, $+V_{DD}$. With the input at $+V_{IN}$, the MOS-FET is biased to the ON condition and the output is at the low logic-level, $+V_{DS(ON)}$. The gate leakage current of the MOS-FET is several orders of magnitude below that of the J-FET. Moreover, it is only slightly affected by voltage and temperature changes. Therefore, I_{GSS} is of only passing interest in the design of the MOS-FET switching circuits.

The remaining static characteristic of interest



10. **Another switching time factor,** capacitance, is not very dependent on bias voltage variations. Both C_{iss} and C_{rss} are reasonably flat over wide biasing ranges in p-channel MOS-FETs (a) and n-channel units (b). Note, however, that $C_{d(sub)}$ (not shown) is voltage dependent—in a square-root fashion.



11. **MOS-FET inverter** switching times as functions of drain current are plotted (a). Here t_{d1} is the turn-on delay time, t_r the rise time, t_f the fall time and t_{d2} the turn-off times are lessened, making the device function faster. delay time. Driving source resistance R_S has a major effect on t_{d1} and t_r (b). As R_S is lowered, these switching

is $V_{DS(ON)}$ (Fig. 9a). The $V_{DS(ON)}$ curves for the MOS-FET resemble the $V_{CE(sat)}$ curves of conventional bipolar transistors. Figure 9a can be used as a design curve in much the same manner as are the $V_{CE(sat)}$ curves of bipolar transistors. For a given drain current—for example 2 mA—the designer wants to know what value of V_{GS} is required to keep $V_{DS(ON)}$ below 0.5 volts. From the intersection of the $I_D = 2$ mA curve and the $V_{DS} = 0.5$ V level, he can see that V_{GS} must be greater than 5.3 volts to ensure that V_{DS} will be below 0.5 V.

From Fig. 8 the voltage swing across the MOS-FET capacitances can be determined. The voltage variation across C_{gs} is simply V_{IN}; the voltage change across $C_{d(sub)}$ is $V_{DD} - V_{DS(ON)}$; and the voltage change across C_{rss} is $V_{DD} + V_{IN} - V_{DS(ON)}$. In short, it turns out to be the same ΔV swing as encountered with the J-FET inverter.

As with the J-FET, the variations of these capacitances and r_{ds} are responsible for the switching behavior. A plot of r_{ds} vs gate-source voltage and temperature for the MM2102 appears in Fig. 9b. For the MOS-FET, channel resistance decreases as V_{GS} is increased. The plot shows the variation of r_{ds} with temperature to be less than that of the J-FET. If $V_{GS}=10$ V, for instance, r_{ds} changes by only 0.15 Ω/°C over the temperature range of −55°C to +125°C. This compares to the 3-Ω/°C variation of the 3N126 J-FET at zero gate voltage.

C_{iss}, C_{rss} immune to bias variations

Parameters C_{iss} and C_{rss} are essentially independent of bias voltage (Fig. 10). The dip in the C_{iss} curves occurs at the start of conduction in the channel. $C_{d(sub)}$ (not shown), however, is a junction capacitance; it varies roughly as the square root of the voltage.

The switching curves for the MM2101 are shown in Fig. 11. For this device, the gate time constant ($R_T C_{gs}$) is short compared to the drain time constant:

$$\tau_{gd} \approx C_{gd}[R_T + R_D r_{ds}/(r_{ds} + R_D)]; \qquad (2)$$

and during turn-on the channel is ON for most of the switching interval. The results are shallow t_{d1} and t_r vs I_D curves. The gate and drain time constants do not track over the current range; consequently, the effect of decreasing the driving resistance R_S as I_D increases appears in the delay and rise time curves.

During turn-off, however, the channel is essentially OFF, and the charge time is determined by R_S and R_D alone. Thus the curves of t_{d2} and t_f vary directly with the drain current.

To emphasize the effect of driving-source resistance R_S on the switching times, the turn-on switching times were measured with a very low source-resistance (Fig. 11b). The turn-on delay time t_{d1} was most drastically affected, while the rise time at low I_D showed a similar improvement. At higher drain-current levels, the source resistor used for the $R_S=R_D$ condition was already low and so the improvement was not as great.

All in all, the switching properties of both J-FETs and MOS-FETs are none too easy to predict, since they depend upon the voltage variation of several characteristics, some of which are interrelated. It will be shown that the switching speed of FETs is comparable to that achieved by many junction transistors operating in the same current range. The dynamic behavior, as a function of the gate voltage, determines the switching performance. A reasonable approach to giving design information, then, is to specify the switching characteristics under a variety of conditions. This approach will be used in the second part of this article, which covers the actual design of J-FET and MOS-FET digital circuits. Moreover, the basic inverter building block will be applied to the NOR and NAND gate logic units which compose the field-effect switching networks. Part 2 of this article will appear in ED 25, Nov. 8, 1966. ■ ■

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4. FM tuner employing FETs has <2.0 μV sensitivity, spurious response rejection > 79 dB

This FM tuner uses both N-channel silicon and P-channel germanium FETs for high performance with simple circuitry and low component costs.

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Circle 294 on Reader Service card for application information on this circuit.

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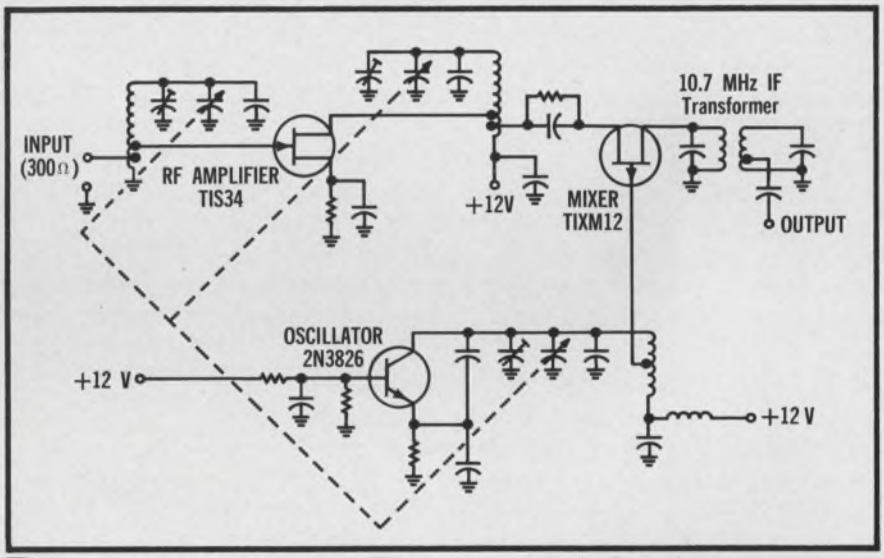

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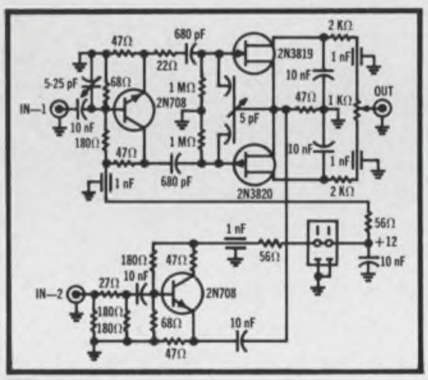

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Reduce thin-film circuit size with this set of design curves that predict thermal effects and simplify circuit design.

To take full advantage of the thin-film technology, circuits should be operated at the maximum permissible temperature and their size reduced to a minimum. In doing this, however, the power rating of a substrate or resistive film cannot be assumed to be constant. Though these ratings are chosen after thousands of hours of life studies, they are not unchanging, but do in fact vary according to circuit size. If this value is taken to be constant, then final designs will often fall short of size requirements.

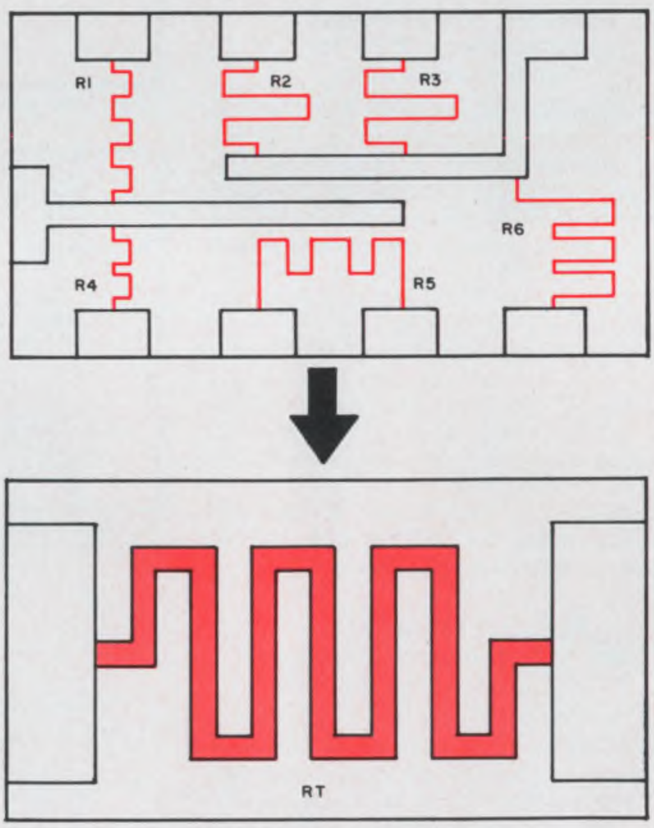
Instead, to determine the power rating more accurately and to apply such information to a specific design easily, try the technique that is described here.

This method neither predicts the temperature of all the resistors in the circuit nor does it determine a circuit design where the resistors will be at a prescribed temperature. Rather, it predicts the hot-spot temperature (the highest temperature on the circuit) and its location in the circuit. With this goes a design procedure that produces a circuit with a predetermined hot-spot temperature. Though the results are far from the ideal solution, this design technique is superior to one that uses the constant watts-per-square-inch rating.

The crux of the method is the assumption that all the resistors in a circuit are equivalent to one resistor that has an area equal to the total area of all the resistors and a power dissipation equal to the total power dissipation, as illustrated in Fig. 1. With this assumption, a series of resistor samples is measured to obtain a relationship between the watts-per-square-inch rating (P_D), temperature (T), and the ratio (r_A) of substrate area (A_S) to resistor area (A_R). Plotting these relationships makes it possible to develop a series of design graphs. These graphs will predict the hot-spot temperature of multiple-resistor circuits or provide circuit design information on the basis of a known hot-spot temperature.

John R. Peek, Development Engineer, Western Electric Co., Inc., Allentown, Pa.

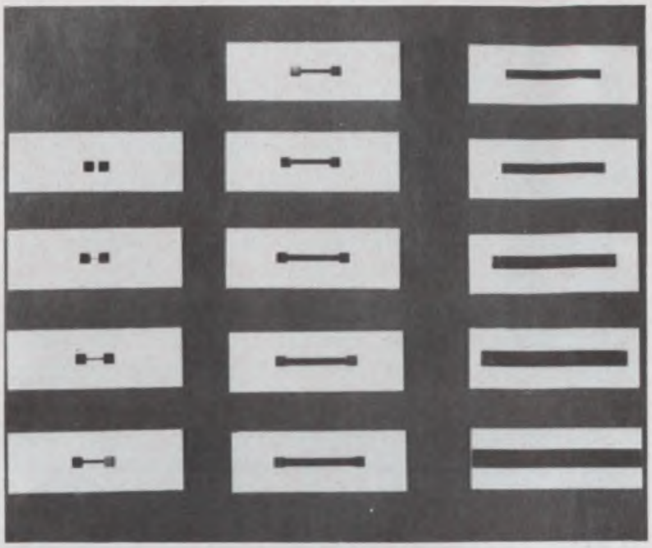
One important point should be emphasized: The graphs given in this article refer to the particular substrate and the particular resistance film developed at Western Electric Co., where the work was performed. Should there be any change in materials, new graphs, using the same techniques, would have to be drawn. The substrate material used here is an unglazed, 25-mil-thick, 99.5% alumina ceramic body. The film material is sputtered tantalum nitride at 35 ohms per square. The leads are solder-dipped copper to a diameter of 23 mils.



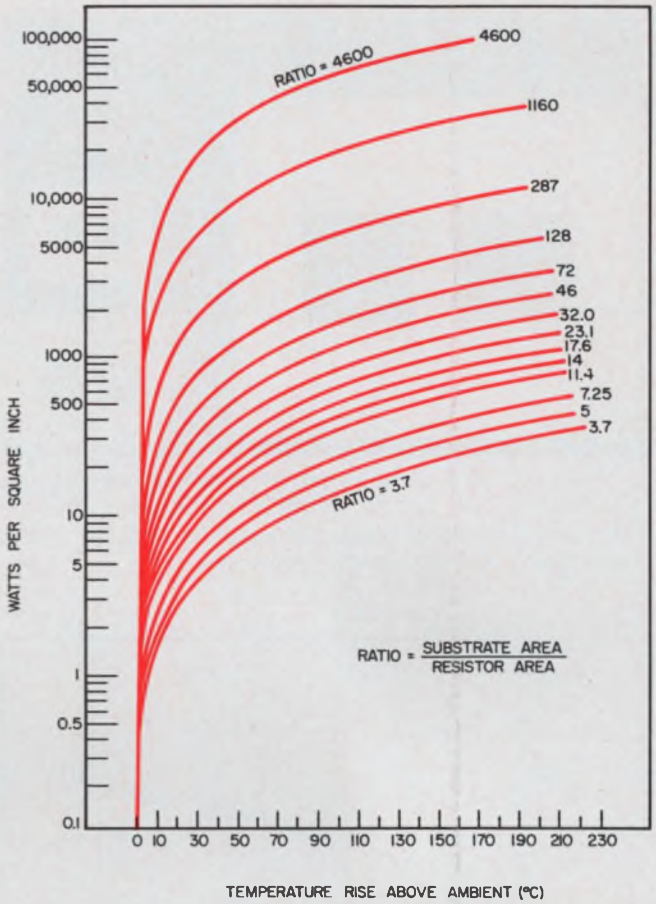
$$A_{RT} = A_{R1} + A_{R2} + A_{R3} + A_{R4} + A_{R5} + A_{R6}$$

$$P_{RT} = P_{R1} + P_{R2} + P_{R3} + P_{R4} + P_{R5} + P_{R6}$$

1. **A single thin-film resistor** approximates the power consumed and the area covered by the thin-film resistor network.



2. **Sample set of thin film resistors** is tested and the test results plotted in the accompanying figures. Note the constant substrate area.



3. **Fallibility of a constant watt-per-square-inch rating is obvious** in this plot of temperature versus power: as the area ratio changes, the power rating varies considerably.

Metered samples provide graph information

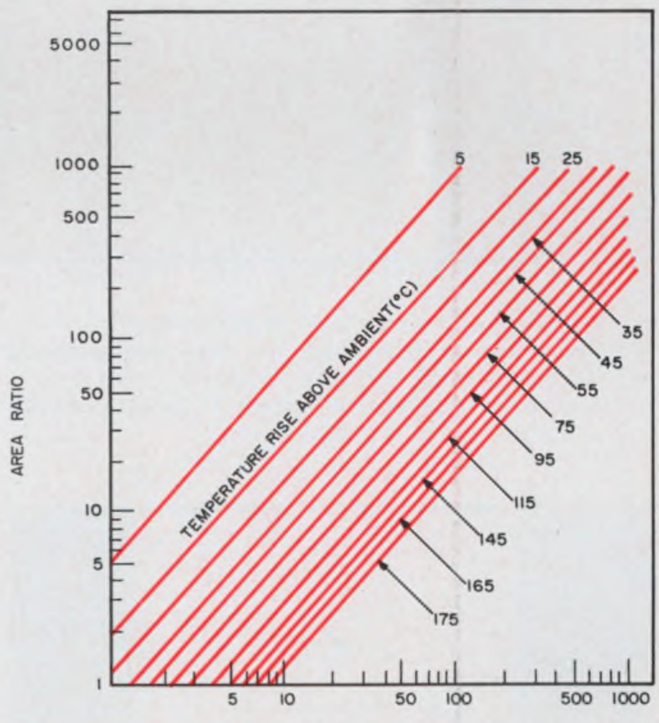
Shown in Fig. 2 are the experimental samples that were used to determine the relationship between P_D (watts per square inch) and film temperature for different ratios of substrate area to resistor area. The area of the substrate (888,-250 square mils = 550 x 1615 mils) and the length-to-width ratio of the resistors (8:1) are fixed. So long as the length-to-width ratio is fixed, each resistor has the same resistance. The resistor area does vary and so, therefore, does the ratio of substrate area to resistor area. The linewidth of the resistors varies from 10 mils to 175 mils.

This set of resistors was then tested by the application of a series of known potentials across each resistor and the simultaneous measurement of the hot-spot temperature with an infrared detecting device. With known potentials and resistances, a family of curves of power per area versus temperature rise above ambient can be plotted, as shown in Fig. 3. Note that the term watts per square inch here always refers to the area of the resistor film and not the area of the substrate.

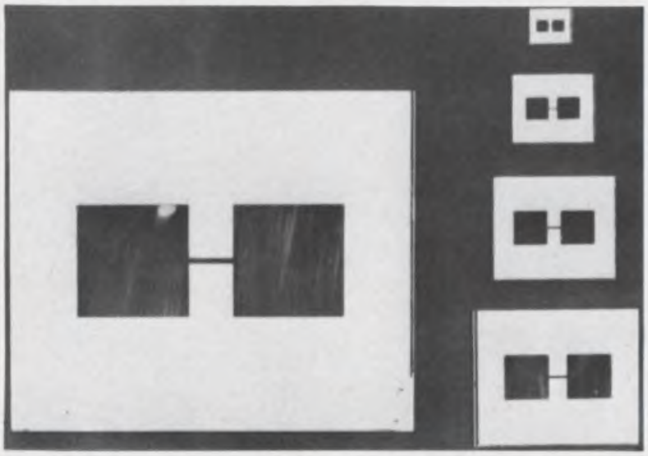
Fig. 3 graphically indicates the fallacy of assuming a constant watts-per-square-inch rating for the rating varies substantially. Figure 3 is hard to use with unlisted ratios, and thus Fig. 4 (extrapolated from Fig. 3) proves much more useful in temperature prediction. With these curves it is possible to predict the hot-spot temperature of any thin-film resistor circuit, so long as all the resistors are assumed to be one resistor. The watts-per-square-inch rating is given by:

$$P_D = 1000\, P_T / A_{RT}, \qquad (1)$$

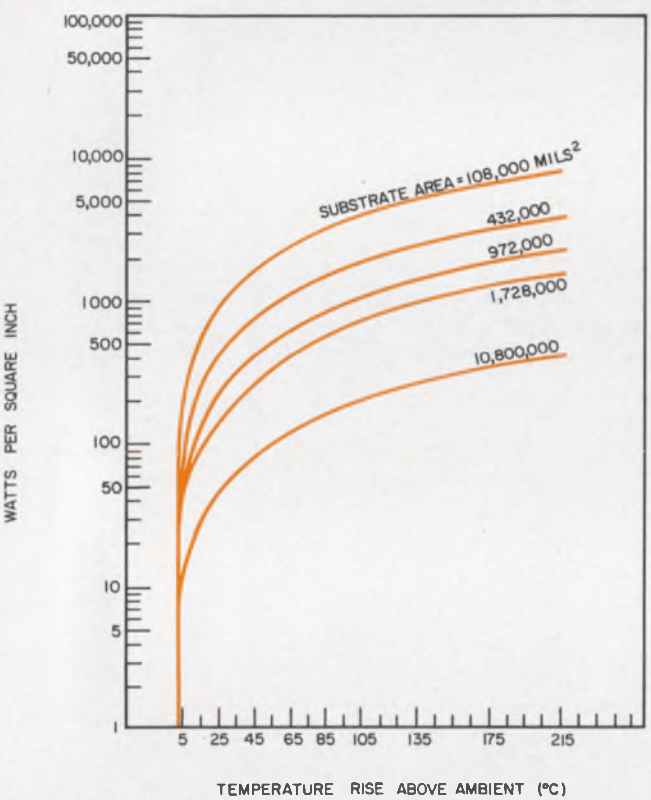
where P_T = total power of the circuit in milliwatts, and A_{RT} = total area of the resistors in square mils.



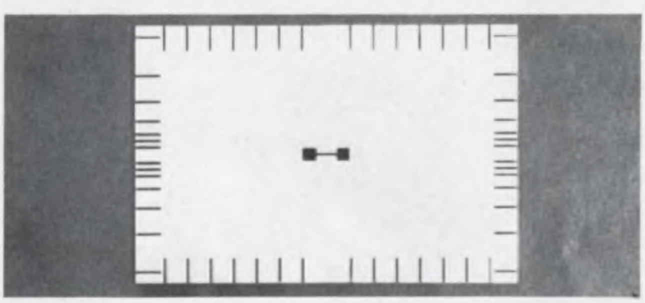
4. **Plot of area ratio versus watts per square inch,** extrapolated from Fig. 3, is useful. The temperature lines refer to the temperature above ambient.



5. **Tests on this sample set of resistors** provide the correction curves for the variation in substrate area. As the substrate area changes, the variation in power rating is so great that it cannot be ignored.



6. **Varying the substrate and film area simultaneously** produces this family of curves. Though the area ratio is constant, there is a large difference in temperature rise as the substrate area is changed.



7. **Sample for temperature variance versus area test** has index lines to denote the various areas that are used.

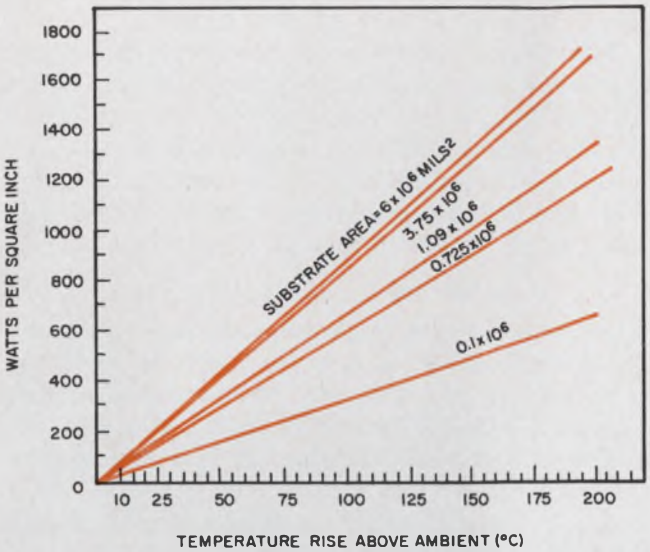
A number of thin-film circuits were evaluated and the measured results compared with calculated results based on these curves. This comparison showed that the calculated and measured results had a high correlation so long as the area of the tested substrate approximated that of the experimental substrate used in determining the curves. When the areas differed, the temperature predictions were inaccurate and this inaccuracy followed a definite pattern: When the tested substrate was larger in area than the experimental substrate, the predicted temperature was lower than the actual temperature; when the tested substrate was smaller, the predicted temperature was higher than the actual temperature.

Evidently, a correction factor that compensates for variations in the substrate area must be developed. To this end the sample resistors shown in Fig. 5 were made. In these units, substrate area to resistor area is kept constant (540:1), while the substrate areas are varied. Linewidths are 5, 10, 15, 20, and 50 mils and the length-to-width ratio is fixed at 8:1. A series of potentials was applied to each resistor and the hot-spot temperature measured. The results, shown in Fig. 6, indicate that, even though two circuits have the same substrate-area-to-resistor-area ratio and dissipate the same watts-per-square-inch value, the temperature varies with substrate area.

One final test was performed to determine the effect of substrate size on the hot-spot temperature. In this experiment, the area of the resistor remained constant while the area ratio was varied by changing the substrate area. The test sample is shown in Fig. 7 and the results appear in Fig. 8. A correction factor, as a function of substrate area, can be developed by calculating the results (from Fig. 4) of a sample, and then comparing these results with the values calculated by using Figs. 6 and 8. The correction curves for temperature and for watts per square inch are shown in Figs. 9a and 9b.

Once a set of design curves has been established, the following procedure will determine the hot-spot temperature of a particular thin-film circuit:

- Total the individual resistor's dissipation ratings to obtain a total power rating (P_T).
- Add the individual resistor area, in square mils, to obtain the total film are (A_{RT}).
- Calculate the watts-per-square-inch rating, using Eq. 1.
- Divide the substrate area by the resistor area to get the area ratio ($r_A = A_S/A_{RT}$).
- Plot the watts-per-square-inch rating and the area ratio on Fig. 4, and predict the hot-spot temperature.
- Determine the correction factor for that substrate area from Fig. 9a, and multiply the predicted hot-spot temperature by this correction



8. **Results of varying the substrate area and the area ratio** of a thin-film resistor. For a given power rating and a two-to-one change in substrate area, the hot-spot temperature can be as much as 10°C higher.

factor to get the actual hot-spot temperature of the circuit.

The number of leads plays an important part in the cooling of the film area. The samples used in the experimental investigations contain only two leads while the majority of thin-film circuits contain many more. An additional correction factor compensates for the variation in the number of leads. This factor was determined experimentally: Circuits were evaluated by applying various potentials to the resistors and noting the temperature change as the leads of the circuit were eliminated one by one. Though the effect per lead varies with film temperature, resistor location and other factors, an average number which provides a reasonable prediction is obtained. For the type of lead used in the investigation (23-mil solder-dipped copper) the temperature effect per lead is 1.1%. A circuit with six leads would thus manage to reduce the actual temperature as calculated by $(6 - 2) \times 1.1\% = 4.4\%$.

Design example has ten resistors

The ten-resistor circuit, shown in Fig. 10, will be used as a design example. The substrate area is 825,000 mils^2 and the circuit has 14 leads.

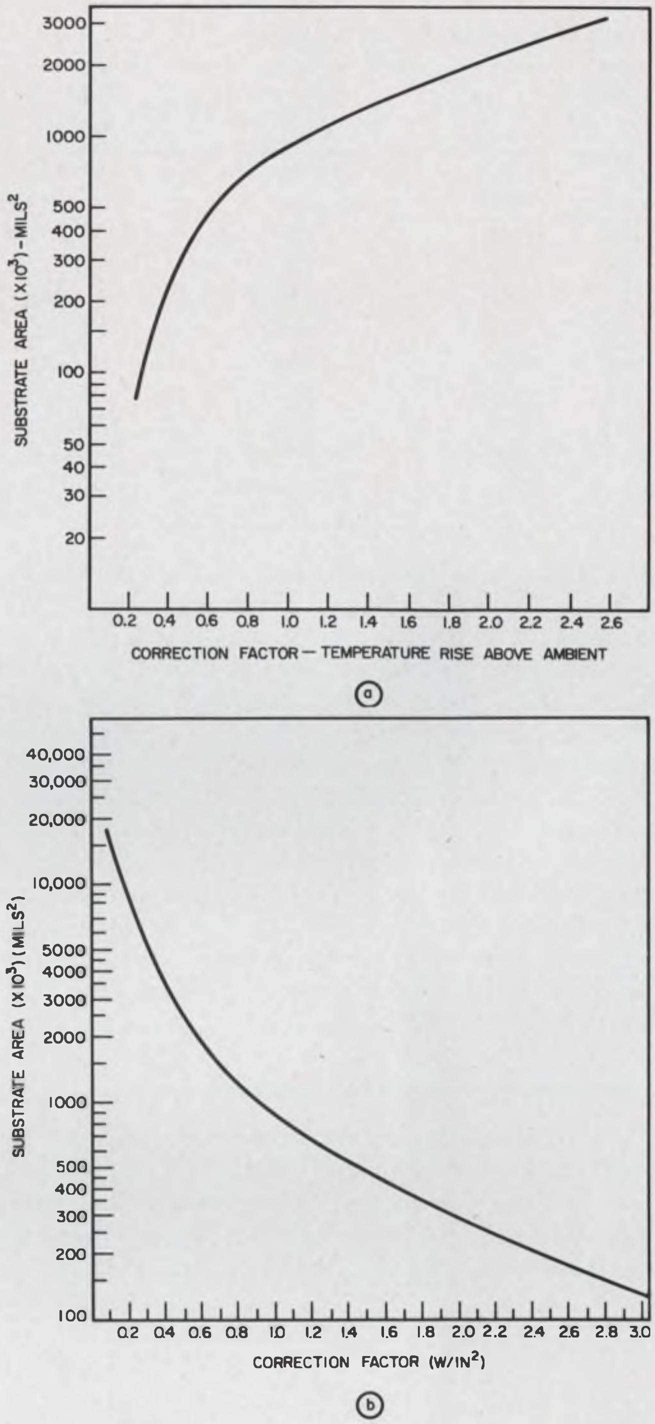
The accompanying Table lists all the individual resistor characteristics as well as the total power rating and the total film area. The next step in the design procedure is to calculate the watts-per-square-inch rating:

$$P_D = 1000\, P_T / A_{RT} = 28.06 \text{ W/in}^2.$$

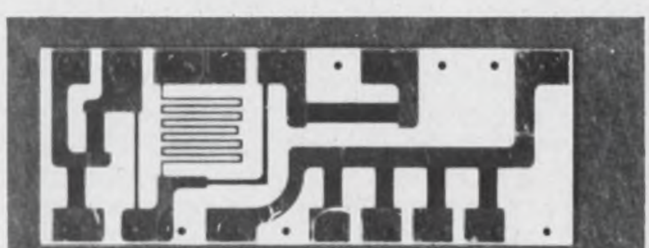
The substrate-area-to-film-area ratio is:

$$r_A = A_S / A_{RT} = 9.25.$$

These values are plotted on Fig. 4 and the rise in



9. **Correction factor for temperature (a) and power rating (b).** The correction factor is equal to 1.0 when the substrate area is 888,250 square mils—the substrate area used in developing Fig. 4.



10. **Thin-film network contains 10 resistors.** The hot-spot temperature (91.2°C above ambient) occurs in the resistor with the highest power-dissipation rating.

Resistor values for circuit example

Resistor (Ω)	Power (mW)	Film area ($mils^2$)
R1 - 80	136	6,272
R2 - 80	136	6,272
R3 - 80	136	6,272
R4 - 80	136	6,272
R7 - 80	136	6,272
R9 - 80	136	6,272
R6 - 201	500	15,840
R5 - 914	100	7,770
R8 - 922	110	4,095
R10 - 12,066	986	24,200
	2512	89,537

temperature is found to be 95°C. Two correction factors, one for substrate areas and one for the number of leads, have to be included. From Fig. 9a, the correction factor for the substrate area is 0.94, and the corrected temperature becomes 89.3°C. The lead correction factor is arrived at by multiplying the 1.1% factor by 12 (14 leads less 2). This factor becomes 13.2% of the temperature rise. Multiplying the temperature rise (89.3°C) by this factor and substracting the result from the temperature rise gives a final calculated temperature rise of 77.2°C. Generally this hot-spot temperature will occur on the resistor that has the highest watts-per-square-inch rating. In this example this would be *R10*.

Circuit design with known temperature

The experimental curves can also be used to design a circuit where the hot-spot temperature is not to exceed a predetermined value. The data curves in Fig. 5 are described by the general equation of a straight line, $y = mx + b$, or

$$\log r_A = m (\log P_D) + \log b, \qquad (2)$$

or

$$\log A_S/A_{RT} = m \log (1000\, P_T/A_{RT}) + \log b. \qquad (3)$$

Since $m = 1.12$ for the substrate material discussed here:

$$\log A_{RT} = 8.4\ (1.12 \log 1000\, P_T + \log b - \log A_S). \qquad (4)$$

Two correction factors must be added to this equation. The first compensates for the decrease in hot-spot temperature due to the heat-sinking effect of the leads. The actual hot-spot temperature (T) is equal to the calculated hot-spot temperature (T') less the effect of the leads (for every lead above two, the hot-spot temperature is lowered by 1.1%). This can be written as:

$$T = T' - (0.011)\ (N_L - 2)T', \qquad (5)$$

or

$$T' = T/[1 - 0.011\ (N_L - 2)], \qquad (6)$$

where N_L = number of attached leads.

The second correction factor compensates for the error due to substrate area. This is not a difficult task. The correction factor, obtained from Fig. 9b, simply shifts the temperature line of Fig. 5 to the left or right. The slope remains the same and thus the only thing that changes in Eq. 4 is intercept b. A new intercept is calculated by:

$$\log b = \log b' - \tan \phi\ (\log CF), \qquad (7)$$

where b is the new y-intercept in Eq. 4, b' is the y-intercept of Fig. 5, ϕ is the angle between the temperature line and the watts-per-square-inch line, and CF is the correction factor from Fig. 9b.

This is a general equation. In this article only the unglazed ceramic is discussed, and thus $\tan \phi$ in Eq. 7 is equal to 1.12; a glazed ceramic would have a different $\tan \phi$.

To design a circuit with a known hot-spot temperature, the procedure is as follows:

- Select the desired hot spot temperature.
- Add the correction for the number of leads in the circuit.
- Determine the power, P_T, that the circuit dissipates.
- Assume a value of substrate area and determine the intercept value b from Eq. 7.
- Calculate A_{RT} from Eq. 4.

A practical example illustrates this concept. Assume the intended circuit will have 12 leads, will dissipate 2000 mW and, to fulfill the reliability and life requirements, will maintain a hot-spot temperature of 100°C at a 25°C ambient. The calculations are:

- The allowable temperature rise is 75°C.
- From Eq. 6, $T' = 86$°C.
- P_T is given as 2000 mW.
- Assume $A_S = 400{,}000$ $mils^2$; from Fig. 9b, $b = 0.22$, $\phi = 48.2$°C, $CF = 1.7$; from Eq. 7, $\log b = 9.08201 - 10$.
- Substitute all these values into Eq. 4: $A_{RT} = 32{,}410$ $mils^2$.

Thus with a substrate area of 400,000 $mils^2$, a total resistor area of 32,410 $mils^2$ would maintain the hot-spot temperature at 100°C at an ambient of 25°C. It is possible that other combinations of A_S and A_{RT} could produce the same result. The idea is to optimize the solution and get the smallest substrate and resistor area that fulfills the circuit requirements. The calculations should be repeated until this goal is achieved.

Naturally, the procedure does not give an absolutely "accurate" answer. There are so many variables that have to be accounted for that this ideal solution does not always work. For example, consider the effect of subsequent heat-sinking of the substrate. The results do, however, provide a method of evaluating existing circuits and of designing new circuits with greater accuracy than by any previous method. ■ ■

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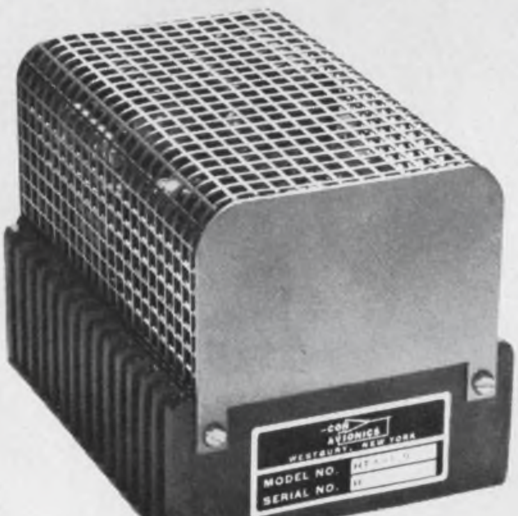

SPECIFICATIONS	Standard Model	"A" Model
Total Regulation (line and load)	±0.5%	±0.05% or 2mv (whichever is greater)
Ripple (rms max.)	10 mv	0.003% or 1mv (whichever is greater)
Temperature Coefficient	0.07%/°C	0.015%/°C or 1.8mv (whichever is greater)

	ALL MODELS
Input	105-125v ac, 47 to 440 cps
Temperature	75°C ambient max. — 90°C base plate max.
Response Time	10 microseconds
Military Specifications	Certified to meet the environmental requirements of MIL-E-5272 and the RFI requirements of MIL-1-6181
Mean Time Between Failure	100,000 hours typical, calculated according to Mil Handbook 217
Short Circuit Protection	Automatic, current limiting

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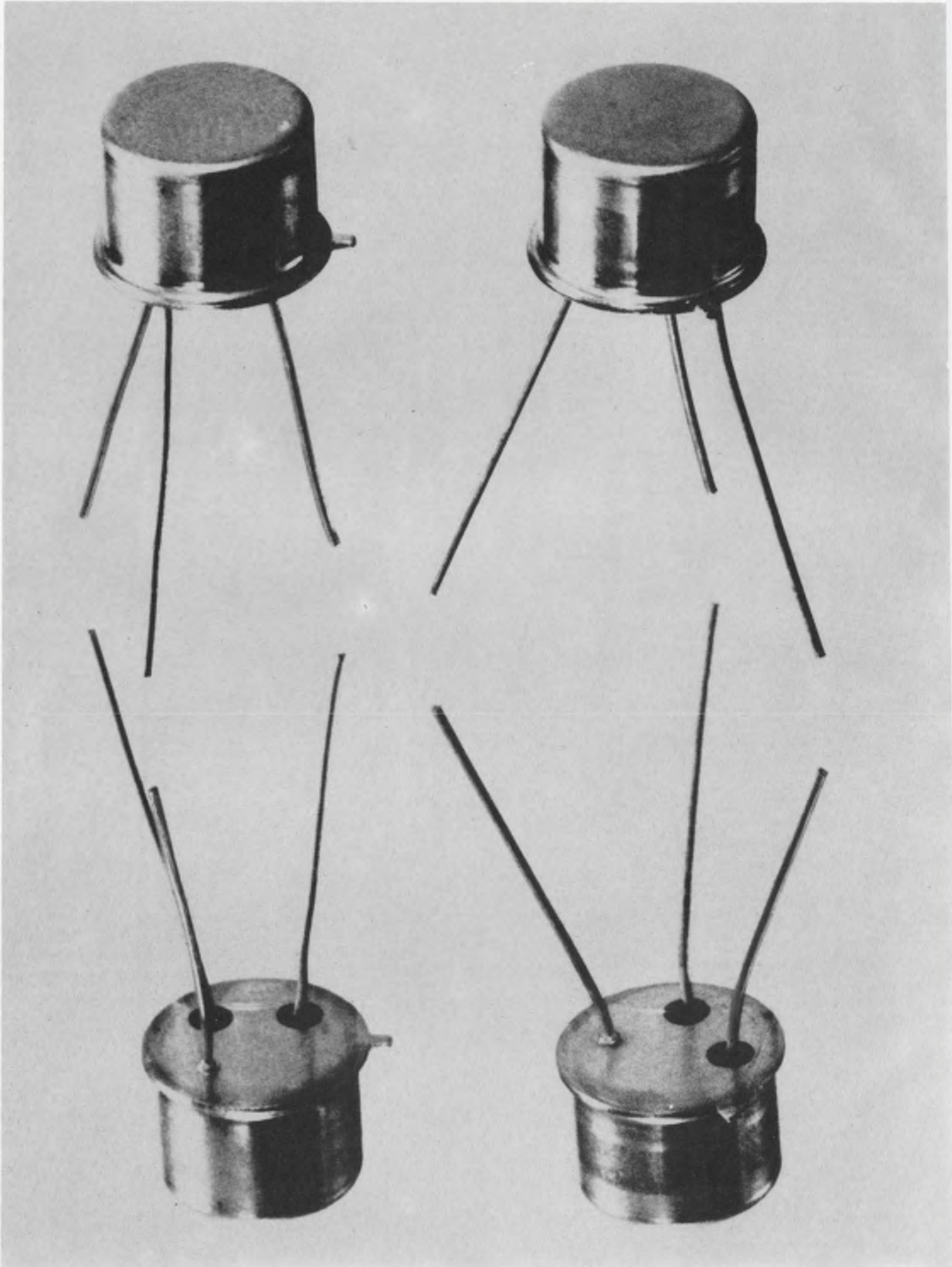


Start your computer design with this comprehensive checklist. It will help you to select the right set of IC modules for the job.

Part 2 of a series

When you select a family of IC logic modules for a digital computer, think first of the functions (adders, decoders, etc.) that the machine will have. This way you will get the most out of the hardware used and cut the number of module types that your design requires. There are two stages in the selection of logic modules:

- Check your function needs against the checklist of generalized module functions (see Box).
- Choose the best set of modules for the job, once you know what your module needs are.

Selection is simplified if the modules are divided into four categories according to their degree of complexity: nonfunctional, semifunctional, functional and system-functional. Each category is based on the operations that the module can perform and on its component density.

The checklist is basically a compilation of the functions that a module set must perform, as discussed in Part 1 of this series.* With each function goes a list of questions about how that function will be implemented in a specific machine. Once these questions have been answered, the designer can analyze the module sets and select that which best meets his design needs.

*See "Digital computers are no mystery," Ed 22, Sept. 27, 1966, p. 86-91.

John Earle, Advisory Engineer, IBM, Palo Alto, Calif.

How to form a module set

In the four categories into which the modules are split, the words "function" and "functional" apply specifically to what the module does—for example, adds, shifts, etc.

- *Nonfunctional*—Every circuit AND, OR, NOT, and their variants NAND and NOR, have all inputs and outputs connected directly to the module pins.
- *Semifunctional*—These modules differ from the previous category in that some of their internal circuits are interconnected on the module or some of their circuits have inputs in common. They thus have more complex but still nonspecific general functions for a variety of functional applications.
- *Functional*—The circuits are interconnected on the module to form specific functions. For example, the module may implement a group of register positions, a slice of an adder, a segment of a shifter, or a portion of some type of checker.
- *System-Functional*—An entire system function is encapsulated on the module. For example, the module may contain an entire adder, a whole shifter, or a complete slice of the data path.

Checklist helps to evaluate module requirements

Registers

How many in gates?

How many out-gates?

Do several registers share a common bus?

Are all bits of a register logically identical?

Are both phases required from the register bits?

Is a separate reset line required?

Does the clock timing philosophy of the machine affect the clock input logic?

Does the register or its out-gates require powering?

Is a double register or single register required?

Shifters

Does it shift left only, right only, or both left and right?

Is it a digital shift (several bits) or a bit shift?

How are end conditions handled when bits are shifted off the end of a word?

Bus

How many data lines are bused together?

Does the bus require a power driver at the output of the OR?

Adder

Is the adder binary, decimal or other?

Checklist continued

What kind of checking features?

Are all bits logically identical?

How many inputs?

Will the inputs be bused at the adder input?

Are there special inputs to certain bits?

How will subtraction be performed: 1's or 2's complement?

Will the adder use a ripple-carry or a high-speed look-ahead, carry-predict or other means?

What are the end conditions?

Is there end-around-carry provision for a "hot one" insert in the low-order bit?

Does one input require a true-complementing network?

Does the output need to be available in both true and complemented form?

What phase of the sum is required?

Checking

What is the checking scheme? Is it parity?

Is parity carried on a digit, byte, half-word, or word basis?

Does a parity tree always drive a latch, i.e., it holds an output after the input is gone? If so, should the latch be included on the module?

What loading effect will checking have on data lines?

Do error signal lines have to be powered?

Leading zero detector

Is normalization done on a bit or digit basis?

Is leading zero detection a critical path?

What output code—binary or one-out-of-n?

Counters

What code will it count in—binary, decimal, one-out-of-n?

Must it count down as well as up?

Does it skip sequences?

What output states must be detected?

Is a counter reset line required?

How fast must it count?

Will a carry-look ahead scheme be required for a fast add-one?

If counting is done in a redundant code, can advantage be taken of "don't care" and "won't occur" states?

Is it a simple counter or is the complexity of state sequence skipping so great that some more general sequence than a counter is preferable?

Do outputs require powering?

Are both output phases required?

Shift register

Will this operate as a simple data shift register or will it have more general use?

Are both phases required at the output?

Have race conditions been taken care of?

Can it be used easily to form a binary counter or a ring?

Must it be capable of forming a set-dominant or reset-dominant trigger?

Will it be used with several inputs?

Does it require out-gating?

Decoders

How many bits must be decoded?

Is it complete decoder? Are all $2n$ input states of n variables to be uniquely decoded?

Will inputs require powering?

Are both phases available on inputs or must they be generated?

Are both phases required at outputs?

Do outputs require powering?

If only a partial decode is required, must there be a facility for adding outputs later?

Should the decoder be gated?

Must it be general-purpose so that it may be usd to form large decoders out of the smaller one?

Control sequence triggers

Should there be double triggers or are latches and triggers separate?

Will there be a complex of input conditions?

Must reset be controllable as well as set?

Is set or reset dominant or are both facilities required?

Are both phases required at output?

Will output require powering?

Will timing philosophy affect the clock logic?

High fan-in gate

Are there facilities for construction of a high fan-in AND and OR? (This usually requires the ability to have an AND drive an AND and an OR drive an OR, otherwise fan-in capability is limited and speed reduced).

Can the high fan-in gates be cascaded to arbitrary depths, for example, for monolithic memories and scratch-pad address decoding and output ORing?

Are both phases required at the output and, if not, should the output be AND or NAND?

Does the output require drivers?

High fan-out gate

Is a power driving facility available when logic fan-out is exceeded? (Facilities must be available for distributing a signal in different directions, especially in clock-powering trees.)

Are the drivers gated?

How much logic is required at the drivers?

Memory stacks

How many registers of how many bits each are to be stacked, fed by a common bus, and driving a common bus?

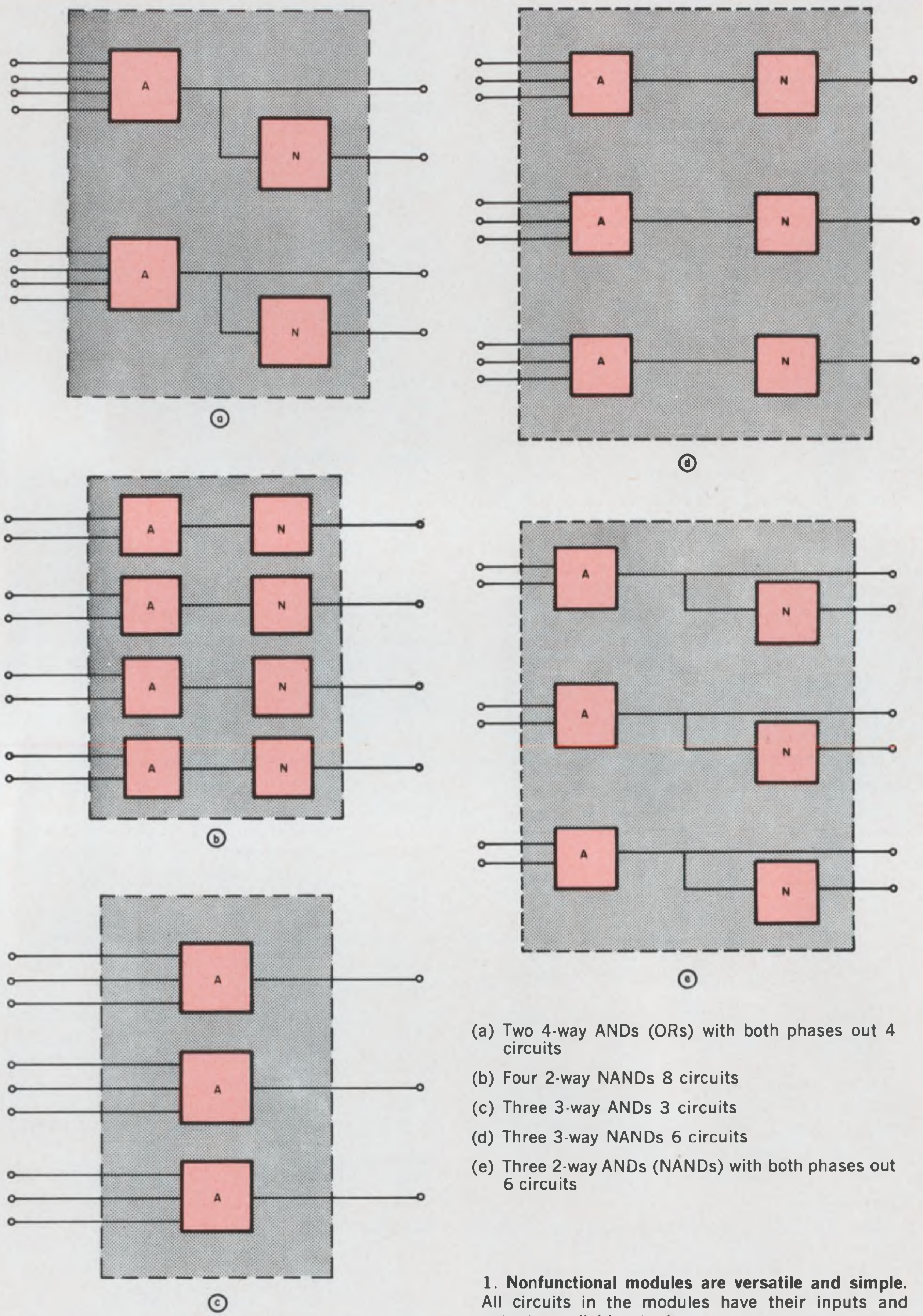
Is there to be more than one in-gate?

Is there to be more than one out-gate?

How fast must the output bus be?

What phase of the output signal is required?

Does the bus require powering?



(a) Two 4-way ANDs (ORs) with both phases out 4 circuits

(b) Four 2-way NANDs 8 circuits

(c) Three 3-way ANDs 3 circuits

(d) Three 3-way NANDs 6 circuits

(e) Three 2-way ANDs (NANDs) with both phases out 6 circuits

1. **Nonfunctional modules are versatile and simple.** All circuits in the modules have their inputs and outputs available at pins.

For a fixed number of module pins, these four categories tend to define modules of increasing density. They also specify an increasing order of difficulty in generalizing about such modules. For example, the system-functional category is entirely machine-dependent, and what can be said generally about modules in this category is therefore very restricted. This category will not be dealt with until later in this series of articles.

The accompanying illustrations are not suggested module sets, but rather are intended to indicate how, in each of the first three categories, a module set might be formed that would implement checklist requirements.

Number of pins has been chosen arbitrarily, and any upper limits on the number of circuits, crossovers or power dissipation have been ignored. No account has been taken of most circuit considerations in this non-hardware-oriented implementation, except for fan-in and fan-out. Nor has any notice been taken of what severe wiring rules in high-performance circuits would do to the design. The more functional types of module are oriented to parallel or serial-parallel machines rather than toward serial-by-bit machines.

For the three categories in question, non-hardware-oriented descriptions in terms of ANDs, ORs and NOTs will be used. We will assume a fan-in and fan-out of four and a module with 12 signal pins (exclusive of voltage).

At each of the three module densities considered, any module set will be presumed to include modules of the lower-density categories—that is, a module set with semifunctional modules may also include nonfunctional modules; a functional module set may include semifunctional and nonfunctional types.

Nonfunctional modules

Figure 1 shows five nonfunctional modules. One prominent characteristic is their symmetry. Each module has a number of identical circuits each of which has the same number of inputs. Symmetry is desirable for parallel data paths; in fact, experience has shown that symmetry is the best way to proceed as a general principle. Provision of both true and complemented phases at the outputs of some of the circuits pulls many otherwise scattered inverters onto the source module.

While more functions could be added to the group in Fig. 1, the modules shown form a versatile group that the designer can use in most design situations. The ratio of unused to used inputs and outputs could probably be improved in some cases, but this "circuit waste" should be considered as a trade-off to obtain maximum module applicability across as broad a range of machines as possible. A comparison of the modules of Fig. 1 against the checklist shows how easily they can be adapted to meet many processing and control functions. For example, the module shown in Fig. 1a can be used to build a leading zero detector for hexadecimal numbers.† The 3-way AND module of Fig. 1c can be used as a basis for a data path register† or for a four-way shifter.†

With such potentials, any designer worth his salt should be able to build his own module set according to his particular circuit requirements.

Semifunctional modules

In the semifunctional category, a module set is of value only to the extent that it is accompanied by a detailed description of the specific functions that each module can be used for. This list should be updated continuously to keep it complete. The versatility of these modules is not always obvious, even to the experienced designer. Therefore, whenever a designer finds a new application for one of these modules, he should document it accurately and completely. This can eliminate time wasted on later duplication of effort. Manufacturers of off-the-shelf semifunctional modules can provide such information.

An idea of the many uses of semifunctional modules is given by the seven modules in Fig. 2. Figure 2a is a high fan-in gate with both phases—that is, both true and complemented versions—out. One input can be brought in as a fast or late input. In general this module can be used as a high-input AND or as an OR.

Figure 2b illustrates the logic that lies at the heart of a carry-look-ahead high-speed adder‡ designed for use as generalized AND-OR logic. It can also be used to build a latch—that is, a circuit that will hold its output even after the input is removed. For example, a latch having a reset to the OR can be made by feeding the output back into an appropriate input.

Another very handy module (Fig. 2c) consists essentially of a power driver on a four-way AND block driving up to 16 loads. Since each driver is gated separately, the module can distribute four out gates on a register. It can also provide clock powering with separate inhibit lines and even perform partial decode functions.

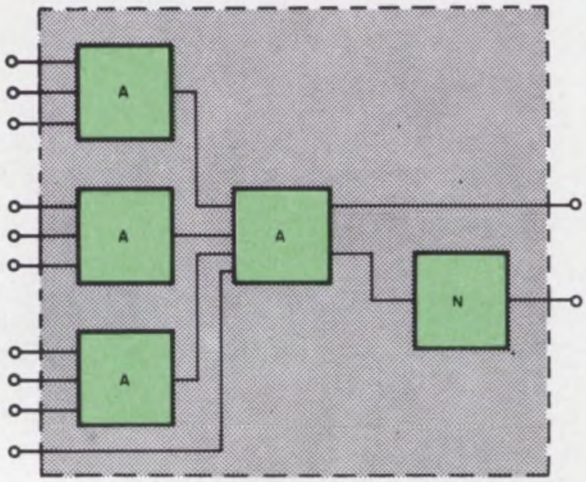
One of the simplest ways to obtain more logic for the same number of pins with semifunctional modules is to have the signal on one input pin drive more than one gate. If this is done judiciously, more logic arrangements can be achieved without significant reduction of the module's usefulness. For example, in Fig. 2d, there are four two-way ANDs, ORed together with both phases out. This is the most common function found in

(text continued on p. 78)

†See illustrations in Part 1.

‡See "Microelectronics Opens the Gate," ED 16, July 5, 1966, pp. 52-57.

Semifunctional modules

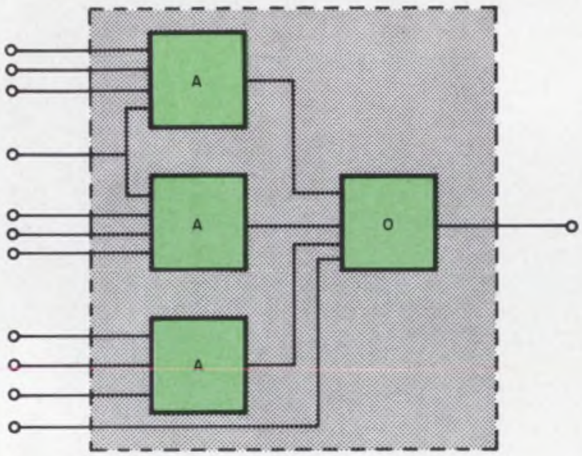


a

(a) 10-way AND (OR) or NAND both phases out (note fast input at bottom) (5 circuits)

Functions:

- High fan-in gate
- Complex interlocks
- Register all-zero detect
- Busing of control conditions to open a gate
- ORing a fat data bus
- ORing of error signals

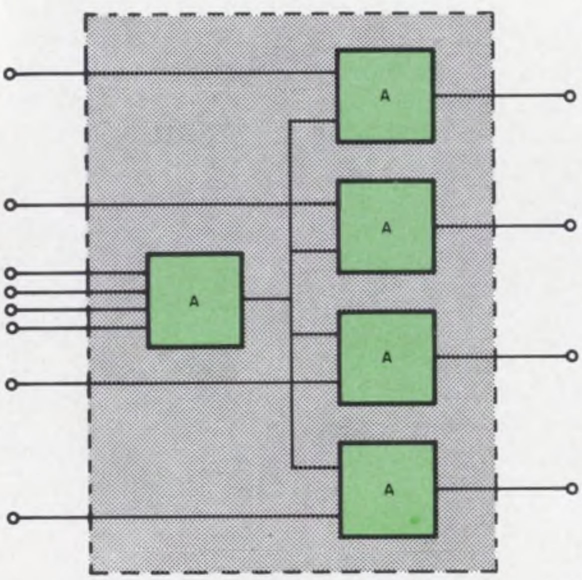


b

(b) Three 3-way ANDs, ORed together with fourth input common to two ANDs, with additional input to OR. (4 circuits)

Functions:

- Latch
- In-gate
- Look ahead carry generate
- Look ahead carry in
- General AND-OR logic

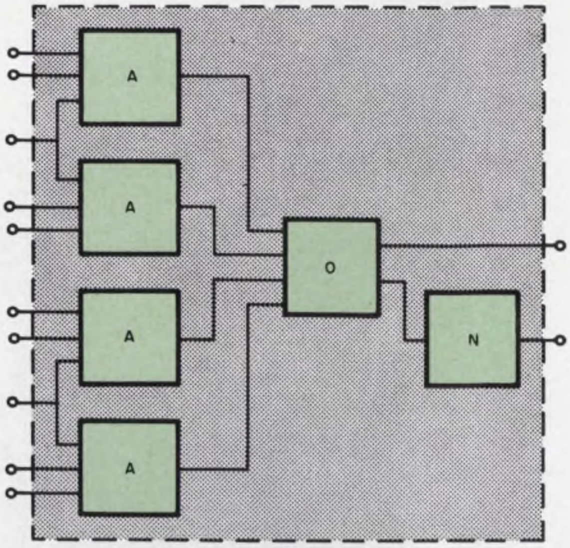


c

(c) 4-way AND driving four 2-way ANDs. (5 circuits)

Functions:

- 4-way AND power driver
- Separately gated parallel power drivers
- Distributor
- Partial decoder

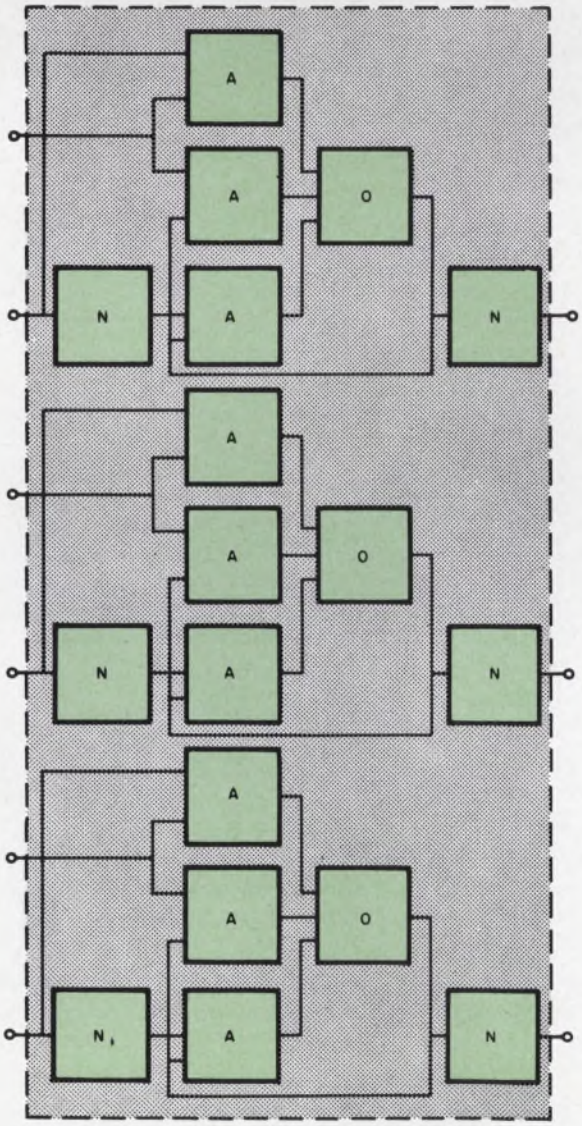


(d)

(d) Four 2-way ANDs, ORed with two additional shared inputs, both phases out (6 circuits)

Functions:

- Bus
- Out-gating
- In-gating
- Shifter
- Three ingate register
- Set dominant control trigger
- Reset dominant control trigger
- ANDs ORed together
- General AND-OR logic



(e)

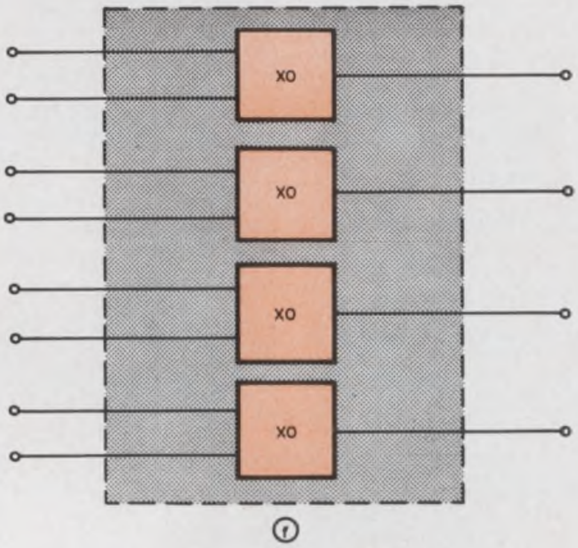
(e) Three latches with both phases out (18 circuits)

Functions:

- Data registers
- Control triggers
- Ring counters
- Binary counters
- Miscellaneous storage

(illustration continued)

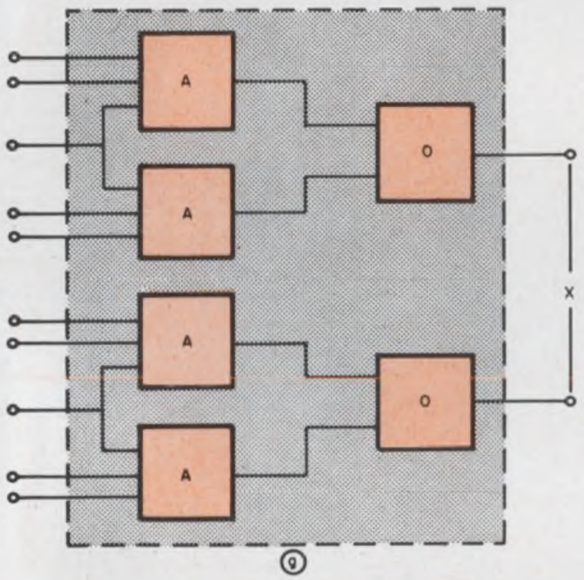
Semifunctional modules continued



(f) Four 2-way exclusive—ORs 20 circuits

Functions:

- True complementing of data
- Parity generation
- Parity checking
- Binary sum
- Comparator
- General equivalence detection

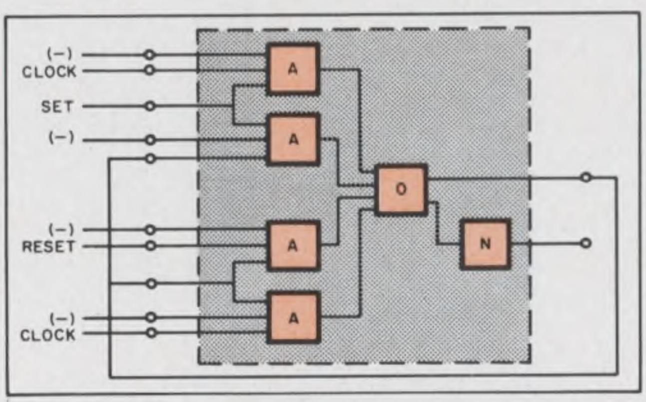


(g) Two 2-way gated AND-ORs. This function can be extended, external to the module, by common-collector dot OR, if circuit family permits.

Functions:

- Gating
- Busing
- Decoding
- Gated latch
- General logic

2. **Semifunctional modules have a variety of applications.** Unlike the modules in Fig. 1, not all inputs and outputs are available externally. These modules are versatile and may be used for many functional applications.



3. **Module of Fig. 2d connected to form** a set-dominant control trigger with separately controlled set and reset [(—) represents biasing which for some circuitry is not required since inputs may float].

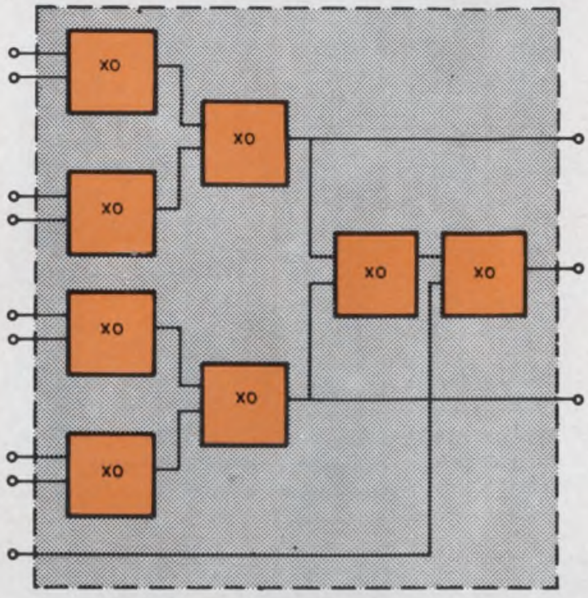
(text continued from p. 75)

data paths (see Part 1). If the inputs are shared between gate pairs, the two remaining pins can then be used to increase the four gates to three inputs. Thus, in addition to the many applications of two-way ANDs ORed together, there is also a capacity for gating or clocking—either separately, in pairs or collectively, or for feeding back to form a set-dominant or reset-dominant control trigger. (These last two configurations are shown in Fig. 12 of Part 1.)

Another use of this same module is shown in Fig. 3, which illustrates how the module can be used as a reset-dominant control trigger with separately controlled set and reset capabilities.

(text continued on p. 81)

Functional modules

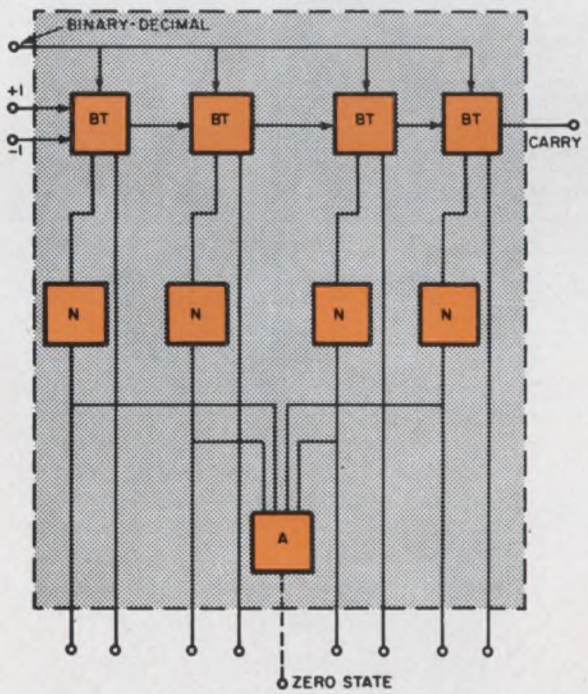


(a)

(a) Exclusive—OR tree 40 circuits

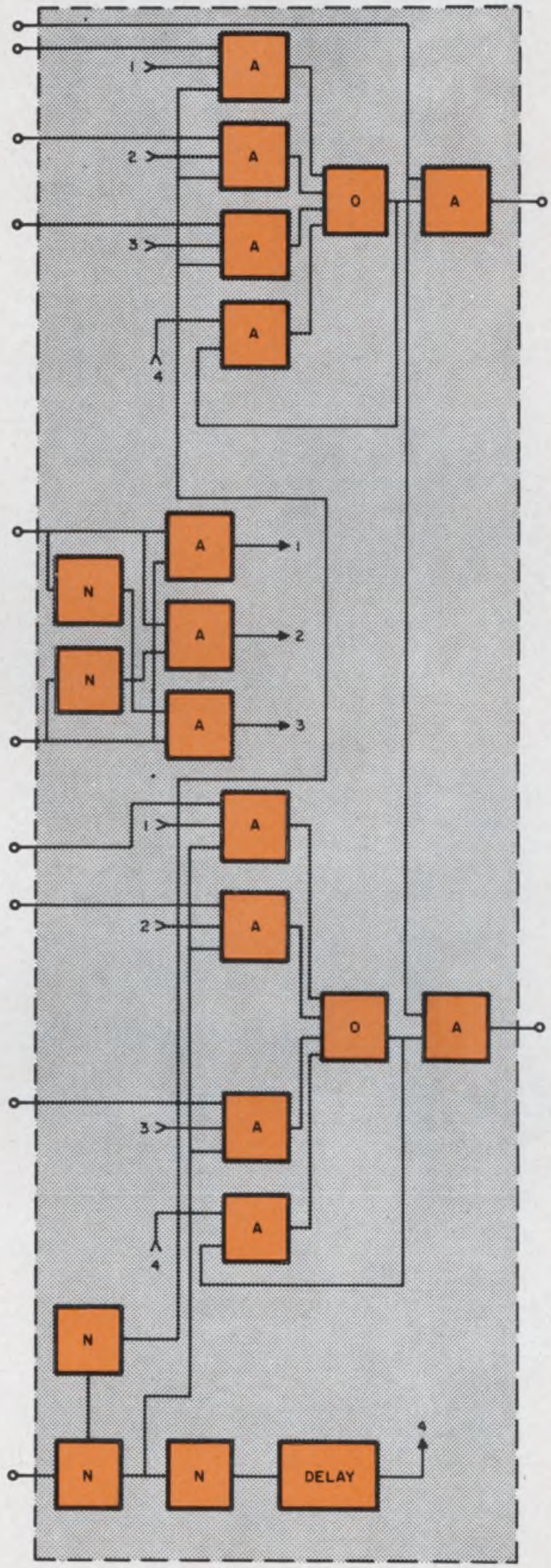
Functions:

- Digital byte parity generation or check
- 4-way, 8-way, 9-way, parity



(b)

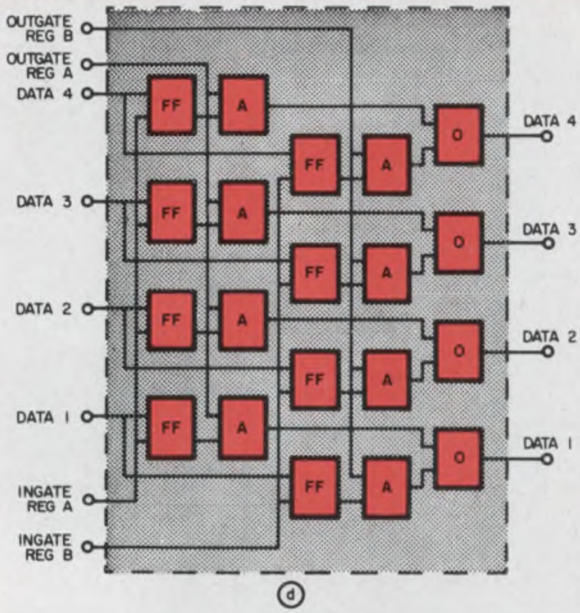
(b) Count up—count down binary or decimal counter (BT= binary trigger) (≈ 50 circuits)



(c)

(c) Two bit three in-gate register with outgate 20 circuits

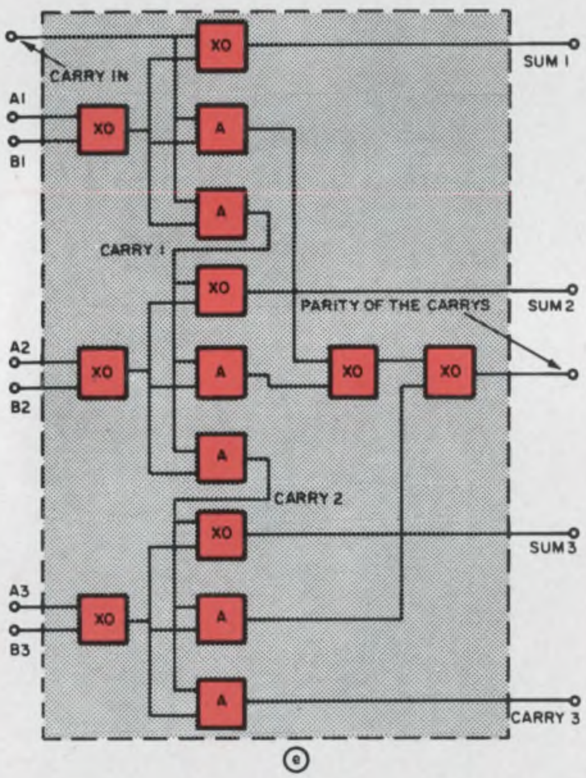
(illustration continued)



(d) 2x4 memory ($\approx$ 55 circuits)

Functions:

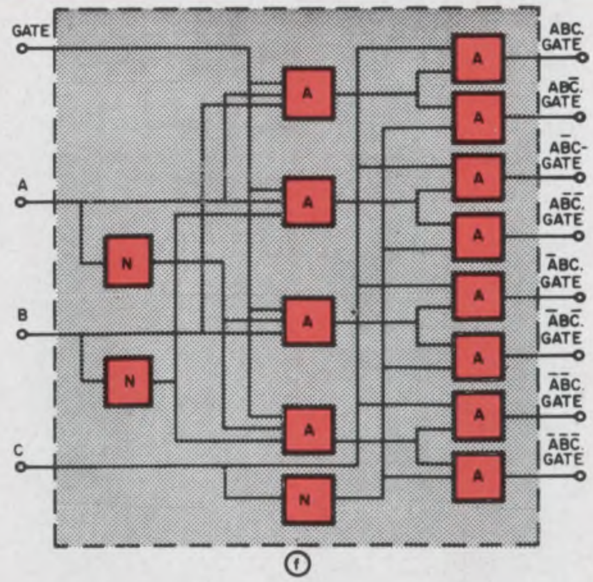
- Memory array
- Two registers driving a common bus



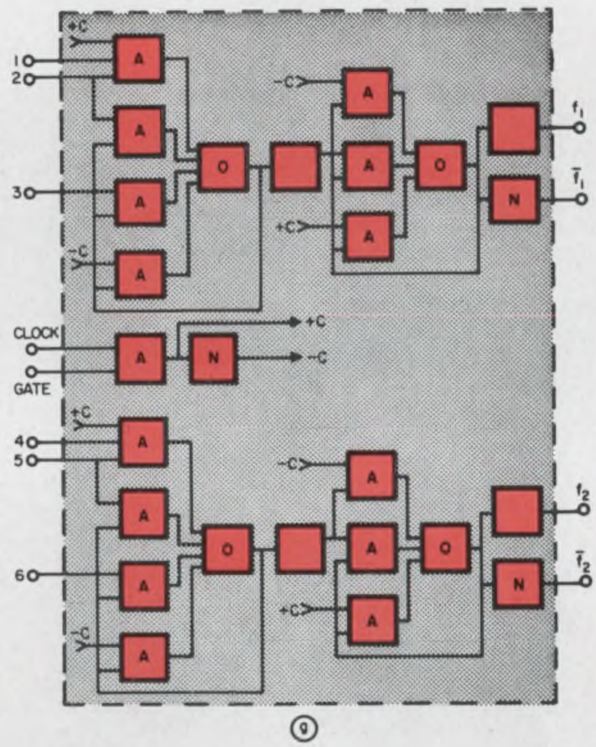
(e) 3-bit adder with carry parity (Carry is duplicated so that single failures are caught in carry lines) (46 circuits)

Functions:

- Binary adder with ripple carry and parity product checking



(f) 3-bit gated decoder (16 circuits)



(g) Two double registers (26 circuits)

Functions:

- Shift register
- Set-dominant control latch trigger
- Reset-dominant control latch trigger
- Binary counter
- Ring counter
- General double register

4. **Functional modules are the most complex** of the three types shown with circuits internally connected to form specific functions. The module may implement a group of register positions, or a part of a shifter, for example.

Likewise an out-of-phase output could be fed back through a delay line to form a gated oscillator out of the module.

The adaptability of semifunctional modules is further pointed up by the three general-purpose latches of Fig. 2e. These can be used in registers, in the second half of double register control triggers, in ring counters, in binary counters and for miscellaneous storage purposes. The module could be designed with four latches, if only one phase-out were adequate.

In the four simple, two-way exclusive ORs in Fig. 2f, the circuit count is based on a design of two inverters feeding two ANDs, which in turn feed into an OR. This module has a variety of general uses—for instance, for true complementation of data in a subtractor, for binary sum formation, in comparators and in general equivalence detectors.

Functional modules

More complex than the semifunctional modules, functional modules contain both AND and OR circuits, plus their variants, interconnected on the module to form specific functions (i.e., part of an adder, shifter, etc.)

Seven functional modules are shown in Fig. 4. The parity tree of exclusive-ORs (Fig. 4a) generates or checks digit and/or byte parity. With this module, parity checking becomes so inexpensive that it encourages increased use of checking.

Figure 4b shows a count-up or count-down counter, in binary or decimal, where there is a choice of having either a carry output or a zero-state indicator. Both phases are available at each of the four bit positions. The detailed logic is not shown specifically, to help emphasize the functional job being performed. Thus the circuit count is only an estimate.

Two bits of a three-bit in-gate register with one out-gate appear in Fig. 4c. The control lines selecting one of the three data bus in-gates are brought in, to conserve pins in encoded form on two control lines instead of three (two bits can represent four combinations). Three of the combinations are used for register selection; the fourth state represents the no-gate-open condition. The delay noted in the diagram is needed to ensure that there will be no timing failure at the latch. There are both logical and circuit means of achieving this delay or its equivalent.

A module that would be used in the formation of a small integrated circuit memory or scratch pad (Fig. 4d) is a 2-by-4 memory array of four bits of two registers with common data-in and data-out buses. The module is general enough to be used in implementing data path registers as well.

Greater density—that is, nine bits rather than eight—could be obtained on this 12-pin module if we had a 3-by-3 array. However, odd-numbered arrays are less generally useful, since data words usually contain an even number of bits. The detailed flip-flop logic is essentially like that of the latches in Fig. 2e.

Another functional module, a three-bit adder, is illustrated in Fig. 4e. Twelve pins are not adequate for a full four bits and, since the three bits implemented need only 11 pins, the twelfth is used for the parity of the carries. (A fourth bit would require two operand inputs plus one sum output for a total of 14 pins per module.) The module illustrated would be used in a parity prediction checking scheme. An alternative module (Fig. 4f) might have a two-bit adder with input-output available in either true or complement form for subtraction. Carry parity and a register on the sum output could also be provided. This would lead to substantially greater circuit density.

A three-bit gated decoded (Fig. 4g) also exemplifies what is essentially an 11-pin function—three inputs decoded to eight outputs. In this module the twelfth pin is used for a gating signal. But for greater density, a latch could be designed into each of the three input lines and the 12th pin used as an in-gate clock control line. This would provide gating as well as temporary storage at the input of the decoder.

For some applications it might be desirable to have the latches on the output lines, although this would require considerably more silicon "real estate," since there are normally more inputs than outputs.

Finally, a functional module may contain two double registers driven by a common clock with the clock gated on the module (Fig. 4h). This furnishes the general functions needed for shift registers, set- or reset-dominant control latch-trigger combinations, binary counters, ring counters, and for general double registers. Running both registers off a common clock and gate line is not a serious restriction.

In computing the average circuits per module for each of the three categories, we find:

Nonfunctional:	5.4 circuits per module
Semifunctional:	9.1 circuits per module
Functional:§	36.1 circuits per module

If a machine were constructed out of the modules of Figs. 1, 2 and 4, and it were assumed that 50% of the modules are nonfunctional, 25% semifunctional and the remaining 25% functional, the over-all average density of the machine would be 14 circuits per module.

These figures provide a rough idea of the densities that can be obtained with a 12-signal-pin module set.

Part 3 of this series will deal with the choice of a logic circuit family. ■ ■

§Choosing the much lower-density module of Fig. 4e rather than Fig. 4f.

Meet any programable or fixed voltage need

Up to 150 volts • Up to 95 amps

A

B

C

CC

D

E


FEATURES and DATA

Full line of accessories and options to meet your system needs. Meet Mil. Environment Specs. **RFI**—MIL-I-16910: **Vibration:** MIL-T-4807A: **Shock:** MIL-E-4970A • Proc. 1 & 2: **Humidity:** MIL-STD-810 • Meth. 507: **Temp. Shock:** MIL-E-5272C • (ASG) Proc. 1: **Altitude:** MIL-E-4970A • (ASG) Proc. 1: **Marking:** MIL-STD-130: **Quality:** MIL-Q-9858: **Fungus Proofing** (optional) all models available with MIL-V-173 varnish for all nutrient components.
Convection cooled—no heat sinking or forced air required
Wide input voltage and frequency range—105-132 VAC, (200-250 VAC, optional at no extra charge) 45-440 cps
Regulation (line) 0.05% plus 4MV **(load)** 0.03% plus 3MV:
Ripple and Noise—1 MV rms, 3MV p to p
Overvoltage protection available for all models up to 70 VDC
High Performance Option—All models available with these specifications for $25.00 extra: **Line regulation**—.01% + 1MV; **Load regulation**—.02% + 2MV: **Ripple and Noise**—½MV rms; 1½MV p to p: **Temp. Coef.**—.01%°C

ACCESSORIES and OPTIONS

System Rack Adapters

LRA-5 • 3½" height by 2 7/16" depth. Price $35.00

LRA-4 • 3½" height by 14" depth. (For use with chassis slides) Price $55.00

LRA-5 and **LRA-4** mount the following combinations of LM models: up to 4 A package sizes • 3 B or 3 C package sizes • 2 A and 1 B or 1 C package sizes

LRA-3 • 5¼" height by 2 7/16" depth. Price $35.00

LRA-6 • 5¼" height by 14" depth. (For use with chassis slides) Price $60.00

LRA-3 and **LRA-6** mount the following combinations of LM models: up to 4 A, B or C package sizes • 3 CC package sizes • 2 D or 2 E package sizes • 2 A, B or C and 1 CC or 1 D or 1 E package sizes • 1 CC and 1 D or 1 E package sizes • 1 D and 1 E package sizes

Metered Panels • 3½" Metered panel MP-3 is used with rack adapters LRA-4, LRA-5 and packages A, B and C. Price $40.00

5¼" Metered panel MP-5 is used with rack adapters LRA-6, LRA-3 and packages A, B, C, CC, D and E. Price $40.00

To order these accessory metered panels, specify panel number which MUST BE FOLLOWED BY the MODEL NUMBER of the power supply with which it will be used.

F and G LM Packages are full rack power supplies available metered or non-metered. For metered models, add suffix M to the Model No. and $30 to the non-metered price.

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WIDE VOLTAGE RANGE

PROGRAMABLE LM SERIES MODELS

PACKAGE A 3 3/16"x3 3/4"x6 1/2"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LM 251	0-7	0.35	0.31	0.29	0.27	$ 69
LM 201	0-7	0.85	0.75	0.70	0.55	79
LM 202	0-7	1.7	1.5	1.4	1.1	89
LM 252	0-7	2.0	1.8	1.4	1.1	99
LM 257	0-14	0.27	0.24	0.23	0.22	69
LM 203	0-14	0.45	0.40	0.38	0.28	79
LM 204	0-14	0.90	0.80	0.75	0.55	89
LM 258	0-14	1.2	1.1	1.0	0.80	99
LM 259	0-24	0.18	0.16	0.15	0.14	69
LM 260	0-24	0.35	0.30	0.25	0.20	79
LM 261	0-24	0.70	0.65	0.60	0.45	89
LM 262	0-24	0.80	0.75	0.70	0.60	99
LM 263	0-32	0.14	0.12	0.11	0.10	69
LM 205	0-32	0.25	0.23	0.20	0.15	79
LM 206	0-32	0.50	0.45	0.40	0.30	89
LM 264	0-32	0.66	0.60	0.50	0.32	99
LM 265	0-60	0.08	0.07	0.07	0.06	79
LM 207	0-60	0.13	0.12	0.11	0.08	89
LM 208	0-60	0.25	0.23	0.21	0.16	99
LM 266	0-60	0.35	0.31	0.28	0.25	109
LM 267	0-120	0.10	0.09	0.08	0.07	109
LM 268	0-120	0.13	0.12	0.10	0.09	119

PACKAGE B 3 3/16"x4 13/16"x6 1/2"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LMB-0-7	0—7	2.8	2.6	2.3	1.5	$109
LMB-0-14	0—14	1.6	1.5	1.3	1.2	109
LMB-0-32	0—32	0.80	0.70	0.60	0.5	109
LMB-0-60	0—60	0.45	0.40	0.35	0.3	109
LM-217	8.5—14	2.1	1.9	1.7	1.3	119
LM-218	13—23	1.5	1.3	1.2	1.0	119
LM-219	22—32	1.2	1.1	1.0	0.80	119
LM-220	30—60	0.70	0.65	0.60	0.45	129

PACKAGE C 3 3/16"x4 13/16"x9 3/8"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LM-225	0—7	4.0	3.6	3.0	2.4	$139
LMC-0-14	0—14	2.2	2.0	1.8	1.5	139
LMC-0-32	0—32	1.1	1.0	0.90	0.80	139
LMC-0-60	0—60	0.60	0.55	0.50	0.45	139
LM-226	8.5—14	3.3	3.0	2.5	2.0	139
LM-227	13—23	2.3	2.1	1.7	1.4	139
LM-228	22—32	2.0	1.8	1.5	1.2	139
LM-229	30—60	1.1	1.0	0.80	0.60	149

PACKAGE D 4 15/16"x7 1/2"x9 3/8"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LM-234	0—7	8.3	7.3	6.5	5.5	$199
LMD-0-14	0—14	4.9	4.2	3.4	2.7	199
LMD-0-32	0—32	2.5	2.1	1.7	1.3	180
LMD-0-60	0—60	1.3	1.1	0.95	0.75	239
LM-235	8.5—14	7.7	6.8	6.0	4.8	199
LM-236	13—23	5.8	5.1	4.5	3.6	209
LM-237	22—32	5.0	4.4	3.9	3.1	219
LM-238	30—60	2.6	2.3	2.0	1.6	239

PACKAGE E 4 15/16"x7 1/2"x11 7/8"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LME-0-7	0—7	12.0	10.5	8.5	6.8	$249
LME-0-14	0—14	7.4	6.4	5.2	4.1	249
LME-0-32	0—32	3.7	3.2	2.6	2.1	249
LME-0-60	0—60	2.1	1.7	1.4	1.1	249

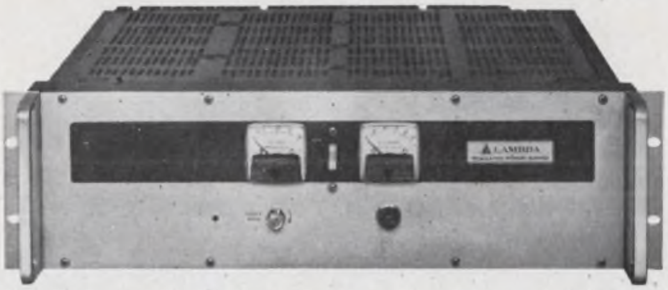
PACKAGE F 3½"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LMF-0-7	0—7	25.0	21.0	17.0	14.0	$425

PACKAGE G 5¼"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LMG-0-7	0—7	35.0	29.0	24.0	20.0	$575

with Lambda Modular Power Supply Systems

F

G



FIXED VOLTAGE RANGE

LM SERIES MODELS

PACKAGE B 3 3/16"x4 15/16"x6 1/2"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF: 40°C	50°C	60°C	71°C	Price**
LM B3	3 ±5%	3.8	3.3	2.6	1.6	$119
LM B3P3	3.3±5%	3.8	3.3	2.6	1.6	119
LM B3P6	3.6±5%	3.8	3.3	2.6	1.6	119
LM B4	4 ±5%	3.8	3.3	2.6	1.6	119
LM B4P5	4.5±5%	3.7	3.2	2.5	1.5	119
LM B5	5 ±5%	3.7	3.2	2.5	1.5	119
LM B6	6 ±5%	3.2	2.9	2.4	1.4	119
LM B8	8 ±5%	3.2	2.9	2.4	1.4	119
LM B10	10 ±5%	2.7	2.5	2.2	1.4	119
LM B12	12 ±5%	2.5	2.3	2.1	1.3	119
LM B15	15 ±5%	2.2	2.0	1.8	1.3	119
LM B18	18 ±5%	2.0	1.8	1.7	1.3	119
LM B20	20 ±5%	1.8	1.6	1.5	1.2	119
LM B24	24 ±5%	1.4	1.3	1.2	1.1	119
LM B28	28 ±5%	1.3	1.2	1.1	1.0	119
LM B36	36 ±5%	1.1	1.0	0.90	0.85	129
LM B48	48 ±5%	0.9	0.85	0.80	0.75	129
LM B60	60 ±5%	0.7	0.65	0.60	0.54	129
LM B100	100 ±5%	0.37	0.34	0.30	0.28	139
LM B120	120 ±5%	0.30	0.28	0.25	0.23	139
LM B150	150 ±5%	0.25	0.23	0.20	0.19	149

NOTE:
Space does not permit listing all LM Series fixed-voltage power supplies. In every package size there are models for each voltage range listed under the B package and all units are multi-current-rated for 40°C, 50°C, 60°C and 71°C. Call or write for data and prices.

PACKAGE C 3 3/16"x4 15/16"x9 3/8"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM C3	3 ±5%	5.3	3.7	$139
LM C4	4 ±5%	5.2	3.6	139
LM C4P5	4.5±5%	5.1	3.5	139
LM C5	5 ±5%	5.1	3.4	139
LM C6	6 ±5%	4.8	3.3	139
LM C12	12 ±5%	4.0	2.9	139
LM C15	15 ±5%	3.5	2.8	139
LM C20	20 ±5%	3.1	2.6	139
LM C24	24 ±5%	2.5	2.2	139
LM C28	28 ±5%	2.3	2.0	139
LM C48	48 ±5%	1.6	1.3	149
LM C150	150 ±5%	0.39	0.33	169

NEW PACKAGE CC 4 15/16"x4 15/16"x9 3/8"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM CC3	3 ±5%	11.0	8.2	$179
LM CC4	4 ±5%	11.0	8.2	179
LM CC4P5	4.5±5%	10.5	8.0	179
LM CC5	5 ±5%	10.5	8.0	179
LM CC6	6 ±5%	9.0	7.7	179
LM CC12	12 ±5%	7.3	5.9	169
LM CC15	15 ±5%	6.0	5.1	169
LM CC20	20 ±5%	5.0	4.2	169
LM CC24	24 ±5%	4.0	3.4	169
LM CC28	28 ±5%	3.5	3.1	169
LM CC48	48 ±5%	2.5	2.2	189
LM CC150	150 ±5%	0.7	0.62	199

PACKAGE D 4 15/16"x7 1/2"x9 3/8"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM D3	3 ±5%	13.1	9.2	$199
LM D4	4 ±5%	13.1	9.2	199
LM D4P5	4.5±5%	13.1	9.2	199
LM D5	5 ±5%	12.6	9.2	199
LM D6	6 ±5%	12.4	8.9	199
LM D12	12 ±5%	10.0	8.3	199
LM D15	15 ±5%	9.0	7.9	209
LM D20	20 ±5%	7.4	6.5	209
LM D24	24 ±5%	6.7	5.8	219
LM D28	28 ±5%	6.0	5.2	219
LM D48	48 ±5%	4.1	3.6	239
LM D150	150 ±5%	1.1	0.90	254

PACKAGE E 4 15/16"x7 1/2"x11 7/8"	ADJ. VOLT RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM E3	3 ±5%	22.0	16.5	$269
LM E4	4 ±5%	21.0	16.5	269
LM E4P5	4.5±5%	20.0	16.4	269
LM E5	5 ±5%	20.0	16.4	269
LM E6	6 ±5%	19.0	15.6	269
LM E12	12 ±5%	15.0	12.3	269
LM E15	15 ±5%	14.0	11.5	269
LM E20	20 ±5%	12.0	9.8	269
LM E24	24 ±5%	11.0	9.0	269
LM E28	28 ±5%	10.0	8.0	269
LM E48	48 ±5%	6.0	4.9	299
LM E150	150 ±5%	1.4	1.2	299

PACKAGE F 3 1/2"x19"x16 1/2"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM FA3	3 ±5%	31.5	24.0	$375
LM FA4	4 ±5%	31.5	24.0	375
LM FA4P5	4.5±5%	31.5	24.0	375
LM FA5	5 ±5%	31.5	23.7	375
LM FA6	6 ±5%	30.5	22.0	375
LM FA12	12 ±5%	22.0	16.2	375
LM FA15	15 ±5%	19.4	15.2	375
LM FA20	20 ±5%	16.0	12.6	350
LM FA24	24 ±5%	14.0	11.4	350
LM FA28	28 ±5%	13.5	10.4	350
LM FA48	48 ±5%	8.1	6.5	375
LM FA150	150 ±5%	2.4	1.8	410
LM F3	3 ±5%	48.0	34.0	425
LM F4	4 ±5%	48.0	34.0	425
LM F4P5	4.5±5%	48.0	34.0	425
LM F5	5 ±5%	48.0	33.0	425
LM F6	6 ±5%	47.0	32.0	425
LM F12	12 ±5%	33.0	22.0	425
LM F15	15 ±5%	28.0	19.0	425
LM F20	20 ±5%	23.0	17.0	395
LM F24	24 ±5%	20.0	14.0	380
LM F28	28 ±5%	19.0	13.0	380
LM F48	48 ±5%	10.0	7.5	425
LM F150	150 ±5%	3.1	2.1	460

PACKAGE G 5 1/4"x19"x16 1/2"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM G3	3 ±5%	95.0	62.0	$575
LM G4	4 ±5%	85.0	62.0	575
LM G4P5	4.5±5%	85.0	62.0	575
LM G5	5 ±5%	80.0	62.0	575
LM G6	6 ±5%	80.0	62.0	525
LM G12	12 ±5%	56.0	37.0	525
LM G15	15 ±5%	45.0	36.0	525
LM G20	20 ±5%	35.0	28.0	525
LM G24	24 ±5%	32.0	21.0	480
LM G28	28 ±5%	28.0	21.0	480
LM G48	48 ±5%	17.0	12.0	575
LM G150	150 ±5%	5.5	4.5	675

* Current rating is from zero to I max. at ambient. Current rating applies over entire output voltage range.

Current rating applies for input voltage 105-132 VAC 55-65 cps.

For operation at 45-55 cps derate current rating 10%.

For operation at 360-440 cps consult factory for ratings and specifications.

** Prices F.O.B. Factory, Melville, N. Y. All specifications and prices subject to change without notice.

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Estimate the boresight error before getting a radome for your radar. For the least error at reasonable cost, you must know the trade-offs.

Radomes introduce errors into the boresight of radars. The question is: How much is the error, what factors affect it and what can be done to reduce it? It is impossible to eliminate the error completely, but careful considerations and trade-offs can reduce it to an acceptable level. The limitations imposed by available materials, structural requirements and environmental conditions are the main points that have to be accounted for.

By definition, the boresight error is the angular deviation of a ray from its true projection as it passes through the radome. The error is due basically to radome curvature and is a function of the incident angle of the microwave ray to the radome surface.

The deviation of the microwave ray as it passes through a single-wall radome may best be understood with the aid of Fig. 1. The deviation angle, D, of the ray from the true projection is given by:

$$D = i_2 - r_2 - i_1 + r_1, \qquad (1)$$

where

$i_{1,2}$ = incident angles of ray to the normals, ($n_{1,2}$), at the points of entering or leaving the radome skin, and

$r_{1,2}$ = refraction angles.

Note that D is the actual boresight error.

Through geometric considerations, D may be resolved to functions of the ratio of interior-incidence-angle thickness to radius, and of the index of refraction. In complete form this equation may be stated as:

$$D = \sin^{-1}[\sin i_1/(1+t/R)] - i_1 + \sin^{-1}(\sin i_1/\mu) - \sin^{-1}\{\sin i_1/[\mu(1+t/R)]\}, \qquad (2)$$

where

R = radome radius,

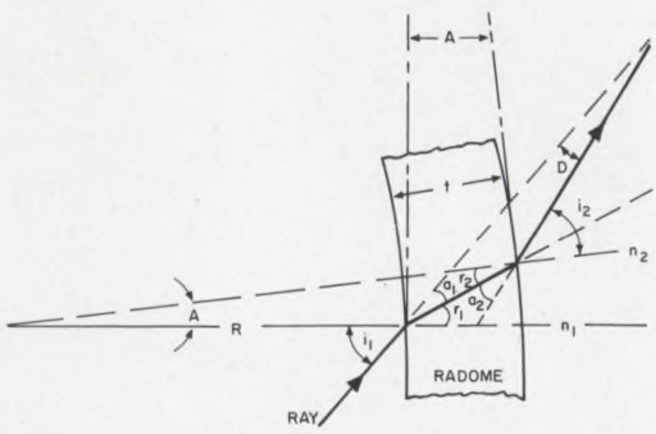
t = radome thickness,

μ = index of refraction = $\sin i/\sin r = (\epsilon/\epsilon_0)^{1/2}$ = (dielectric constant)$^{1/2}$.

Milton B. Punnett, Asst. Chief Engineer, Birdair Structures, Inc., Buffalo, N. Y.

Theoretically the beam at the antenna and radome center will not be deflected. The error is introduced only where the incidence angle of the beam is other than 90°. For example, consider a parabolic dish in the center of the radome. The angle of incidence of the reflected rays is largest at the edge of the dish. This increase in the angle results in increasing boresight error, which, in turn, introduces a diffusion, or spread, of the antenna pattern. In practice the boresight error is also affected by the dielectric constant of the material at microwave frequencies, the thickness of the material and the radome's diameter. Let's examine the effect of each individually.

Angle of Incidence. The greater the angle of incidence, the greater the boresight error. This is shown quite clearly in the graph of Fig. 2. By simple deduction it may be seen that, when considering boresight error only, the antenna should be located at the geometric center of the radome in order to minimize the angle of incidence. This, however, may not always be feasible because of the antenna design (such as with a horn antenna), or where the resultant radome would be signifi-



1. **Deviation of the microwave ray,** as it passed through a single-wall radome is the boresight error, D. It is determined by the index of refraction, the interior angle of incidence, i_1, and the thickness-to-radius ratio, t/R.

cantly oversize and economically unjustifiable. By oversize is meant that the radome is much larger than needed merely to house the antenna with a reasonable amount of clearance (6-8% of the antenna's radius is considered a minimum clearance).

Dielectric Constant. The exact effect of increasing the dielectric constant is not readily apparent from inspection of the equations. In typical applications, an increase in dielectric constant tends to increase the boresight error. The dielectric constant may be controlled by careful compounding of the coating. Unfortunately, it is much easier to increase the constant (by adding such materials as carbon black or titanium dioxide) than it is to achieve and hold a small reduction.

Thickness. As t is reduced, the angle A in Fig. 1 approaches zero and the radome's skin resembles two parallel surfaces with zero spacing. This configuration would obviously reduce error to zero. It may thus be concluded that reducing the thickness will reduce the error. It is also clear that such measures will reduce the physical strength of the radome. The relation of reduced thickness for improved electrical performance vs increased thickness for improved physical properties is frequently a basic trade-off in radome design. Some specific dimensions, which are typical of actual installations, are used as examples in the graphs.

Diameter. An increase in the radome diameter tends to reduce the boresight error, as shown in Fig. 3. This is true even if the angle of incidence remains the same, and even though the thickness may have to be increased to obtain sufficient strength. Other factors, such as increased transmission loss through the thicker skin, must be considered in the over-all selection.

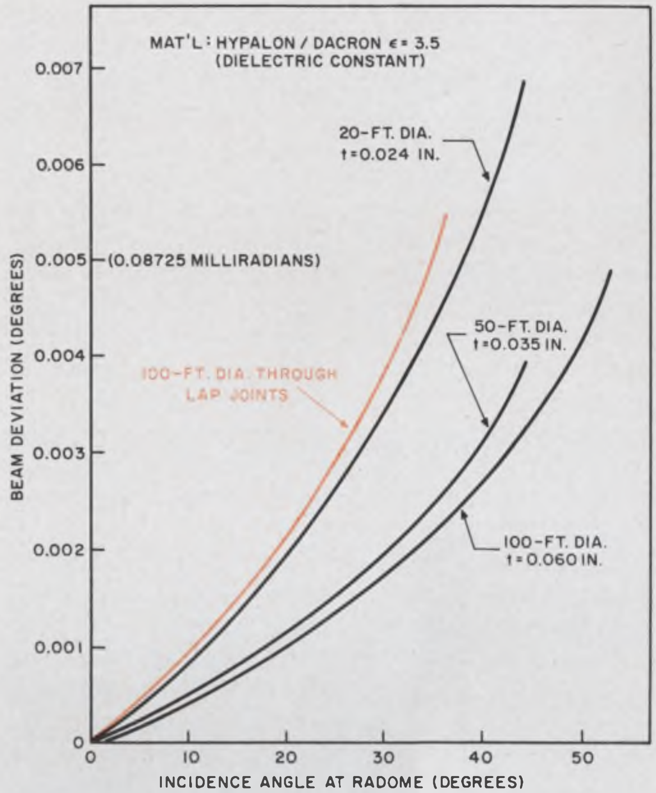
The price is high for good materials

Although many compounds and fabric-coating materials are available, three basic types are used for the majority of air-inflated radomes.

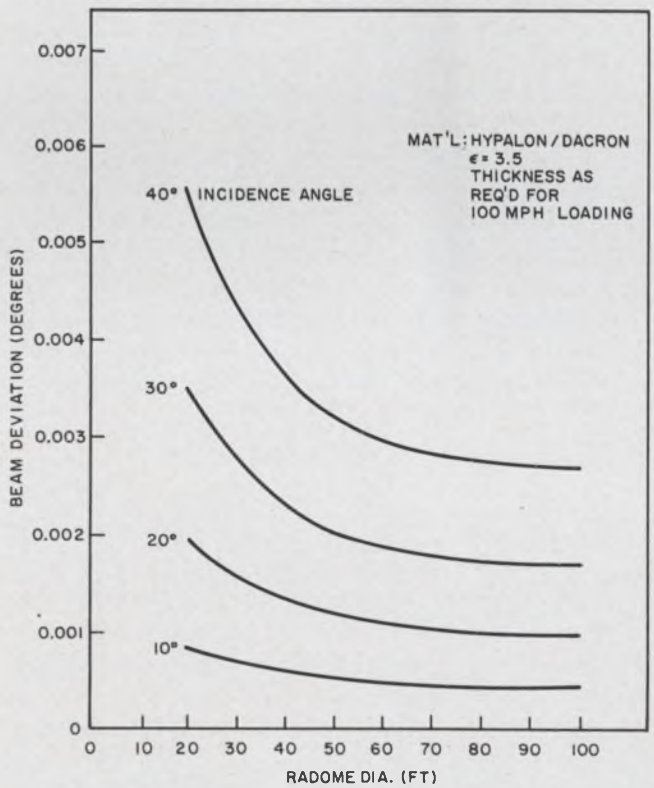
Neoprene with nylon fabric is structurally sound and allows easy fabrication. However, it normally has dielectric constants exceeding 4, even in the most favorable compounds. It also tends to absorb water.

Hypalon with Dacron fabric is used today in the majority of critical radome applications. It has superior strength, life, and electrical performance compared with the original neoprene materials. With careful compounding, the dielectric constant can be held at 3 to 3.5. It is the most expensive material and normally custom-made for specific applications.

Vinyl with nylon fabric is the least expensive. In most cases it also has the lowest dielectric constant, frequently averaging 2.5 to 3. Unfortunately, its fabrication does not lend itself to two-



2. **Boresight error increases** with the angle of incidence, which is measured from the normal at the point of incidence. Considering boresight error alone, the antenna should be located at the geometric center of the radome. The error doubles through the lap joints (in color).



3. **An increase in the radome diameter tends to reduce** boresight error, even though the wall thickness may have to be increased too. The curves are plotted for a single-skin air-supported radome.

plying and this it is not possible to develop the strength characteristics of the Hypalon-Dacron. In addition, the plasticizer tends to be dissipated during exposure and thus its service life is not equal to that of the Hypalon.

A general idea of the range of application for these three basic substances may be formulated. Bear in mind, however, that in each case there can be considerable latitude in the selection of base fabric, plying, and coating. In addition, different safety factors normally apply to each material, and these factors are frequently modified for applications of unusual exposure or service.

Neoprene-nylon is available in two-ply thickness up to approximately 0.050 inch, which is suitable for radome diameters of up to about 110 ft with 100-mph wind loads.

Hypalon-Dacron has been used in two-ply thickness up to 0.072 inch in radomes of 210-ft diameter with 100-mph wind loads.

Vinyl-nylon is available in single-ply thickness up to approximately 0.030 inch. With 100-mph winds loads, this is sufficient for radomes slightly over 50 ft in diameter. Of course, larger diameters may be used where maximum winds are below 100 mph, or where shorter life, reduced safety factor and increased wind distortion are acceptable.

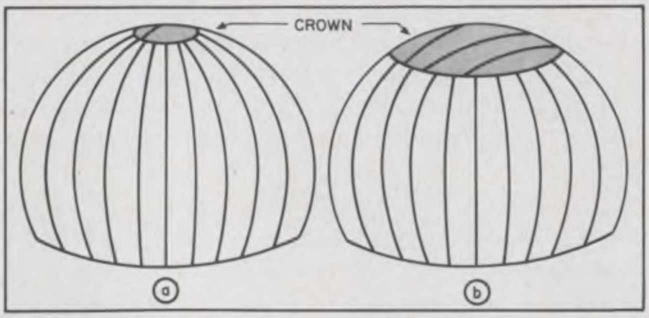
In all three compounds, materials as thin as 0.008 inch are available in a single ply. Such material, however, must be used with care as it is susceptible to accidental abrasion and tear damage.

It should be realized that only certain thicknesses are readily available, even though it is possible to develop a specific material for a specific application. A very limited selection is available as stock from the various suppliers. A much larger selection is available from previously developed combinations (whose specifications may be considered as proprietary to a particular radome fabricator), and special thicknesses can generally be produced if they are compatible with physical requirements. It is the responsibility of the purchaser or radome fabricator to insure satisfactory properties and assume any associated risk.

Examples illustrate typical errors

As the most frequent application involves Hypalon-Dacron, the following example and the graphs shown are based on this material (Two-ply Hypalon-Dacron is used on all the larger air-inflated radomes covering the satellite communication antennas in the United States, France, Germany, and Canada.)

Consider the case where a 100-ft diameter radome is required. A typical high-strength radome of this size would have a total thickness of 0.060 inch. Assume that the antenna is offset 13 ft from the center, which results in an angle of incidence of 15°. Calculation of the boresight



4. **Errors through the lap joints may be reduced** by careful design. Conventional construction increases the number of joints near the crown (a). Multiple-gore crown area cuts back joint concentration near the crown and reduces boresight error (b).

error would be:

$$R = 50 \text{ ft} = 600 \text{ in.},$$
$$t = 0.060 \text{ in.},$$
$$t/R = 0.0001,\ 1 + t/R = 1.0001,$$
$$\mu = (\epsilon/\epsilon_0)^{1/2} = 3.5^{1/2} = 1.872,$$
$$i = 15°,\ \sin i = 0.2588190.$$

Enter these values into Eq. 2:

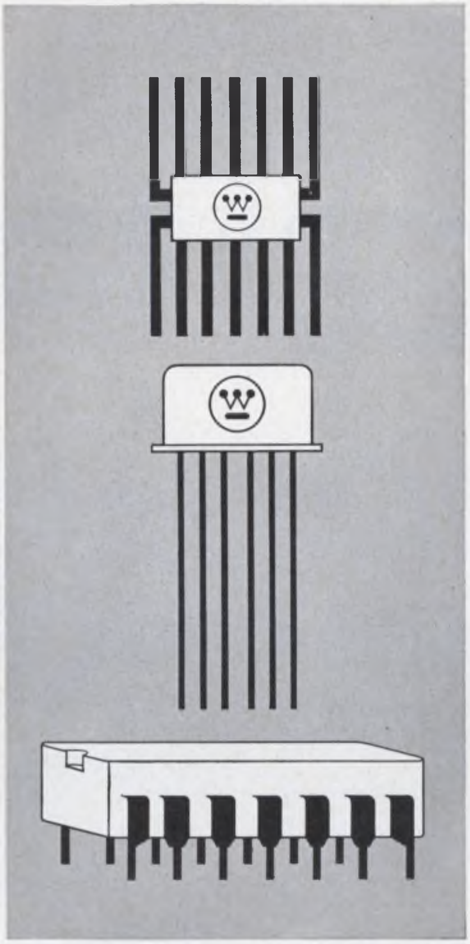
$$\begin{aligned} D &= \sin^{-1}(0.2588190/1.0001) - 15° \\ &\quad + \sin^{-1}(0.2588190/1.872) \\ &\quad - \sin^{-1}[0.2588190/1.872(1.0001)] \\ &= -0.007408°. \end{aligned}$$

The minus sign indicates that $a_1 < a_2$ in Fig. 1 and the beam is deviating away from the straight projection.

The deviation for three typical radomes, as a function of angle of incidence, is shown in Fig. 2. In each case the actual thickness corresponding to each radome size has been used. (Each radome was designed for wind loads exceeding 100 mph.)

The error doubles through the lap areas where the radome panels are joined together (Fig. 2). Even though the lap joint is only about 8% of the total surface area, in normal radome gore patterning the concentration of lap joints increases towards the crown. This tends to increase the error in this region to the vicinity of the values shown for the lap joint. Repatterning the crown area (Fig. 4) and selection of premeasured, low-boresight-error material for the crown region can reduce the error. Such techniques increase costs and, on large radomes, result in longer lead time, since a significant portion of the material must be received, tested and assigned a location prior to assembly.

The incident angle may be converted to the distance from the center of the radome for a specific ray. This would correspond to a specific point on an antenna dish when the antenna is located at the center of the radome. For example, if an 80-ft parabolic reflector is centrally mounted in the 100-ft radome, the beam deviation at the edge of the dish would be 0.005°. A mounting error of 0.0004 inch in a 6-ft section of an antenna at one edge of the dish would yield the same error as that caused by the radome. ■ ■



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A manager can't do it all himself. Learn to delegate authority, and you'll be coordinating a highly successful project group.

Maybe you're not a manager now, but you may be tomorrow. Your chances of success will be immeasurably improved if you follow one basic principle: delegate work wisely.

A manager's effectiveness depends upon his ability to get work done through people. He must delegate work so efficiently that high productivity results, with profits to his company. To achieve this, a healthy, cooperative atmosphere must exist between employee and manager.

Delegation of work is an art. It takes conscious effort to cultivate certain attitudes. If you aspire to be a successful manager, here are three rules to start with:

- Keep an "open mind."
- When an employee makes an honest mistake, try to turn it to advantage.
- Don't overdirect subordinates.

The manager must be receptive to new ideas, new methods. This does not mean that all managerial decisions must be subject to debate by employees. But there is such a thing as listening to suggestions from them. There is such a thing as tact in issuing orders and seeing that they are carried out. And what employee doesn't appreciate praise for a job well done?

One of the easiest things in the world is to fly off the handle when a subordinate makes a mistake—particularly a mistake that looks costly at first glance. It takes a trained manager to analyze the mistake for possible gain. How many discoveries, after all, resulted from "mistakes" in the laboratory?

Of course, we all know how irritating it can be to be assigned a flexible job and then have the supervisor stand over us and hound us until, step by step, the job is finished in precisely the way he would have done it himself. Such a manager wants automata, not people, on his staff.

Let's observe a good manager in operation. John is the engineering chief of an electronics plant. One day he had to supervise a fairly tough job: the mechanical attachment of a 0.003-in.-diameter tantalum wire to an OFHC copper base. He set down his guidelines for a proposed method and discussed the problem with Harry, one of his engineers. Harry suggested that a swaging method—quite different from John's approach—might work out better. John listened. The idea seemed to have merit, but he cautioned Harry on several difficulties that could arise. He mentioned the extremely tight work schedule that the plant had to meet, but gave Harry the green light to try his idea.

Within a day, when John checked the progress on the job, Harry admitted that dimensional tolerance of the copper had been lost with the swaging method. Discouraged, he was about to scrap his idea. John took stock of the situation and discussed the positive aspects of Harry's method. He particularly noted that the swage method did a better job of fastening than had been achieved before and that the dimensional loss in the copper was due only to upsetting the material in the wrong direction.

"What can you do to your swage tool that will move the metal down and in toward the lead wire?" John asked Harry.

A day later Harry came in with a handful of parts that were better than any ever before produced by the company. And within a week there was a bonus: an automatic wire feeder, spinner and cut-off mechanism—made possible by the original swage tool.

A little encouragement goes a long way.

(continued on p. 90)

Louis S. Saiia, Director, VALTEC/Value Technology, Sunnyvale, Calif.

Steps to follow for successful delegation

Planning

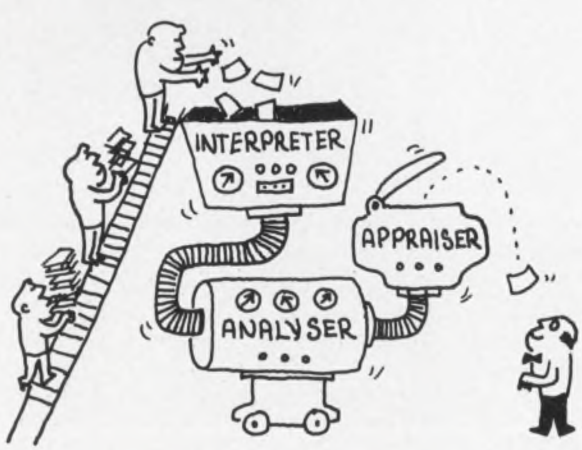
- Determine the objectives of the work to be performed.
  - Analyze past and present trends.
  - Elicit ideas and participation from person to whom you intend to delegate work.
- Establish policies and goals.
  - Determine priorities for the objectives.
  - Anticipate obstacles or difficulties to be encountered and select practical steps to overcome them.
  - Anticipate interface with other organizations and devise means for coordinating with them.
- Formulate ideas, schedules and standards of performance; be realistic in your planning with respect to time schedules, budget and manpower.
- Make the objectives and plan known to all who will be affected.
- Use the results of Measuring to adjust the work of Planning.

Integrating

- Show the common purpose that integrates all aspects of this work.
- Obtain sincere voluntary acceptance of the assignment.
- Encourage individual self-development.

Organizing

- Determine and classify the work required by dividing it into manageable components.
  - Classify into logical and easily understood kinds of work.
  - Don't overload subordinates with responsibility and work.
- Assign the proper authority needed to accomplish the work.
  - Define responsibility, accountability and authority (both that required for the job and that which will be reserved).



Measuring

- Establish a measuring system that has an orderly recording and reporting method (informal oral reports; weekly, semimonthly or monthly written reports; and a formal quarterly report).
- Create an interpreting, analyzing and appraisal system.
  - Appraise by comparison with other projects that are similar in nature.
  - Determine performance and deviations.
- Adjust the Planning stages to reflect the measured results.

Ralph J. Cordiner, president of General Electric, has passed this bit of advice on to those who would be good managers:[1]

> "The work of the manager requires conscious selection of the tasks reserved for himself. Then it requires deliberate delegation of everything else to others in the organization within the framework of his well-designed organization pattern, *no matter what wrench this will require* from his working habits."

Executives like Cordiner have found that, though there are no absolute laws for dealing with people, there are general methods of good management that are effective.

The American Management Association lists 15 problem areas to avoid in delegating authority.[2] Here they are, rephrased into five "don'ts" and five "do's":

▪ Don't use vague language when you delegate work. For instance, suppose you want a contract reviewed. Don't just ask your engineer to review the specifications. Clearly establish what the objectives are and set down guidelines in clear, readily intelligible language.

▪ Don't use haphazard and poorly organized ideas. Many managers have a tendency to say that it they want anything done right away, they have

to do it themselves. Actually, this is merely a cover-up for their own shortcomings and false starts, for each of their own abortive beginnings helps them to clarify more exactly what they in fact want. Now, if they plan carefully before any work commences, they will avoid most mistakes regardless of who does the job.

▪ Don't assume that the person to whom you delegate work automatically knows what you want done. Spell it out for him specifically, and include background details, if these are important.

▪ Don't talk down to employees. Listen to their suggestions. Many of us have spent so much time in classrooms, either as students or teachers, that we tend to revert to the classic professorial role when we become managers in industry. Employees resent being treated as dense students. So do managers, only they sometimes forget how irritating it can be.

▪ Don't nag after you have delegated work. Establish your reporting and follow-up schedule before you delegate the task. That's the time to make it clear that the schedule will be adhered to, unless something unforeseen occurs to change it. Explain that if something should threaten the deadline, you must be informed.

The moral of these "don'ts" is clear: if you want to delegate work successfully, you must first get your own house in order.

Then make these "do's" part of your routine:

▪ Do select the proper employee for the job. Know the abilities, limitations and work needs of your staff. Assign projects and work within an employee's capacity but also keep him stretching for new knowledge and skills.

▪ Do use examples and demonstrations, if necessary, before turning a subordinate loose on his own. Good delegating practice is a training tool. By informative examples, visual aids and effective presentation, the manager sets the pace of his organization.

▪ Do limit the number of orders given at one time. There is no set rule on this, but if the length or complexity of the job warrant it, break down the instructions into small, logical parts.

▪ Do allow reasonable time schedules. Take into account contingencies aside from the time that it might normally take to perform the task—the ability to procure scarce materials, for example.

▪ Do follow up in an orderly fashion. Demonstrate a genuine involvement with your staff. Tour the shop, look over the work in progress, tackle on the spot any special problems that your employees

might be having. Save open criticism of work for private meetings in your office.

When Harry S. Truman was President, he had a now famous sign on his desk: "The buck stops here." The sign was a reminder that some jobs, some responsibilities can't be delegated to others. You alone must face these. You simply cannot, for example, delegate to anyone else the responsibility for disciplinary action or for matters of standard company operating policies.

Finally, remember this: the fact that you delegate authority doesn't mean that you are no longer answerable for your subordinates' mistakes. Upper management will still hold you at fault. And that's why it's to your advantage to delegate authority wisely. ▪▪

References:

1. "Professional Management in General Electric," *Better Business Management Course* (Schenectady, N. Y.: General Electric Co., 1954), Book 3.
2. M. J. Dooher (ed.), *Pointers on Giving Orders* (American Management Association, 1956).

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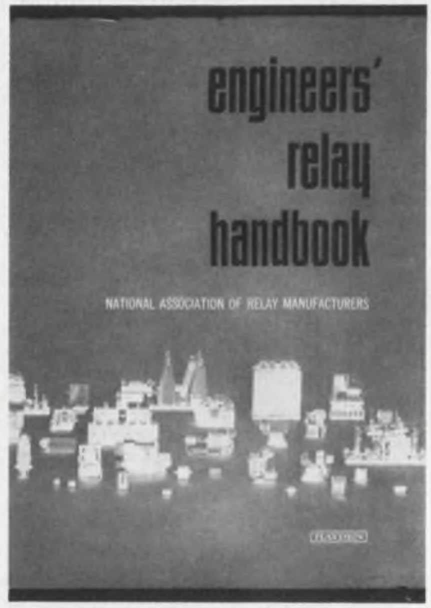

Relay Handbook

Over 32 member companies of the National Association of Relay Manufacturers have joined forces to produce this definitive relay reference work. The book will serve readers as a comprehensive source of information on the operating principles, properties, performance characteristics, application requirements, specifications and testing of the numerous relay types now in use.

The organization and language of the book are aimed at the relay user rather than the relay designer. This in itself makes it unique from previous works of its kind.

While the book provides a thorough discussion and description of relay technology, the main emphasis is practical. In this context, an entire chapter is devoted to the considerations involved in specifying the right relay for a particular application. Other chapters describe the different classes of use and the relays developed for these classes; explain the measurement and expression of relay reliability; and demonstrate the effective use of government and military specifications, with a discussion of the problem of overspecifying. The appendix contains extensive information valuable to engineers for the incorporation of relays into circuits or

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Electronic Drafting and Design, Nicholas M. Raskhodoff (Prentice-Hall, Inc., Englewood Cliffs, N. J.) 594 pp. $15.95.

Electronic cable

A general introduction explains in detail the design, construction and handling of various types of modern electronic cable—including installation techniques. It gives advanced information, presenting the latest state-of-the-art on cable design, specifications and applications.

This handbook covers specific applications in detail, devoting sections to cables for intercom systems, hi-fi, home entertainment systems, f-m, two-way radio, etc. Covers military and nonmilitary specifications.

An appendix contains many useful tables and a glossary. Written in easily understood terms it is intended as a comprehensive guide for everyone who uses or specifies electronic cable.

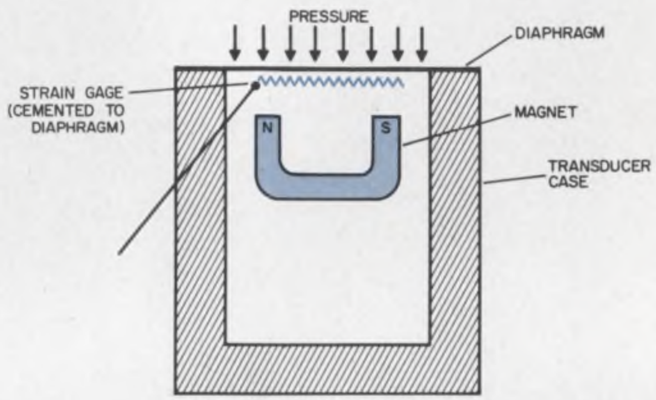
Electronic Cable Handbook, Engineering Staff of Belden Manufacturing Co., (Howard W. Sams & Co., Inc. Indianapolis, Ind.) 244 pp $3.95.

Magnetostriction boosts output of strain transducer

The magnetostrictive properties of nickel wire can be used to design wire strain-gauge transducers that have larger outputs than conventional types.

Present wire strain-gauges normally consist of a bridge arrangement of alloy wire, such as constantan, and deliver low-level millivolt signals as outputs. If the strain-gauge wire is changed to Nickel 204 or Nickel 205, which are magnetostrictive, and a magnet is incorporated into the transducer, the output signal level can be considerably improved.

A device of this sort is shown in the illustration. The nickel element consists of four wires: two in tension and two in compression. As the wires are strained they enter and leave the strong magnetic field produced by the magnet. The change in the magnetization of the wires produces, by magnetostriction, a change in their length additional to that produced by the applied pressure. As a result, a greater resistance change and therefore a larger output signal are generated.



Magnetostrictive property of the nickel wire increases the output signal level of this bonded strain-gauge pressure transducer.

The magnet's field should be aligned so that the lines of force lie in the same direction as the strain-gauge wires. For best results a permanent magnet is desirable.

A basic experiment can demonstrate the operation of the magnetrostrictive transducer. Construct a 100-ohm bridge, using a Weston Aircraft or Lewis temperature bulb as one leg. When a magnetic field is applied to the bulb, the flux that enters through the bulb shell will produce large output signals.

Edwin Kaufman, Research Specialist, Lockheed-California Company, Burbank, Calif.

VOTE FOR 110

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SEND US YOUR IDEAS FOR DESIGN. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component, or a cost-saving design tip to our Ideas-for-Design editor. If your idea is published, you will receive \$20 and become eligible for an additional \$30 (awarded for the best-of-issue Idea) and the grand prize of \$1000 for the Idea of the Year.

One-shot offers high power and no stand-by current drain

High-current, square-cornered pulses are available with this one-shot which draws no current while the circuit is on stand-by. The circuit (see illustration) operates as follows:

Initially, *Q1* and *Q2* are OFF and *C2* has no charge across it. A small positive pulse is applied to the base of *Q1* which immediately starts to turn ON. The collector of *Q1* pulls down the voltage at the base of *Q2* and *Q2* starts to turn ON. The voltage across *R5* increases and turns *Q1* ON harder. This regenerative action continues until both transistors are fully ON. As capacitor *C2* charges through *R3*, the voltage across *R3* decreases and reduces the current in *Q1* and *Q2*. When the current from the base of *Q2* becomes too low to sustain *Q2* in saturation, the voltage across *R5* starts to decrease thus shutting OFF *Q1*. With *Q1* shut OFF, no current can flow from the base of *Q2* and *Q2* will shut OFF. Capacitor *C2* then discharges through *R2*, R3 and *R5*. If *R5* is of a low value, and if diodes are placed across *R2* and *R3* as shown, a fast recovery time will be obtained.

In the circuit shown, the minimum input pulse requirements are 2.5-V amplitude and 0.04-μs pulse-width. The output pulse into 20 ohms is of 26-V amplitude and 1-ms duration. The output

These new Bourns Power Supplies are not only the smallest available, they are the toughest! Both are specifically designed for advanced instrumentation systems where miniature size and exceptional environmental performance are mandatory. The ½ cubic inch Model 3960, with an output of 5VDC and 0-100mA, is ideal for multiple transducer excitation; while the even tinier Model 3965 (5VDC, 0-5mA) is suitable for single transducer use.

Both models feature a completely isolated and regulated DC output. Carefully designed circuits insure protection from reverse polarity, short circuits, and overvoltage. Bourns extensive experience in molding of plastics has resulted in sealed modules impervious to moisture and salt spray. Other outstanding environmental characteristics are wide temperature range of -55 to $+100°C$, 100 G shock and 20 G vibration. High quality microminiature components are used throughout the modules. Bourns Model 4210 Microtransformer is used in the converter circuits and a small TRIMPOT® potentiometer adjusts the output voltage.

Bourns famous Reliability Assurance Program guarantees performance by thorough inspection and test of each unit and by periodic requalification to all published specifications. All units receive a 100-hour burn-in prior to shipment for added reliability.

As for delivery, these units are SHELF STOCKED. Convince yourself how good these power supplies are. Send for detailed technical data. Certified test data is available on request.

SPECIFICATIONS	Model 3960	Model 3965
Input Voltage Range	24-32 VDC	24-32 VDC
Nominal Output Voltage	5.000 VDC	5.000 VDC
Setability	±0.005 V	±0.010 V
Load Current	100 mA	5 mA
Line Regulation, 24-32V	0.1%	0.3%
Load Regulation	1.0%	Not applicable
Temperature Shift, max. -55 to $+100°C$	0.01%/°C	0.01%/°C
Output Isolation at 100V	1000 megohms	1000 megohms
Size	1" x 1" x .50"	.73" x .5" x .52"
Weight	0.60 oz.	0.24 oz.

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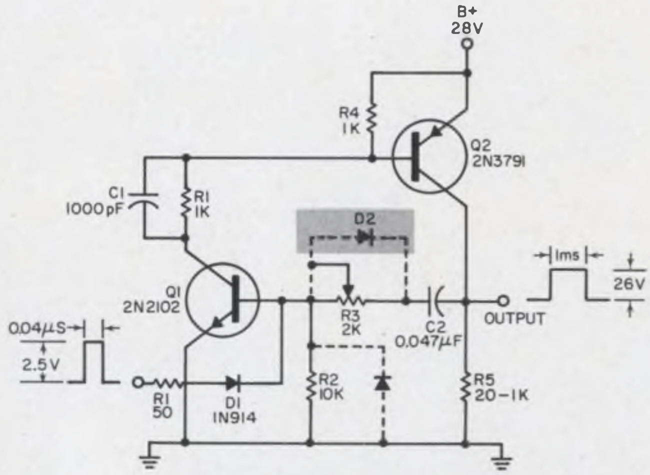


Transistor one-shot delivers high-current and square pulses with no stand-by current drain. Diode D2 speeds recovery time.

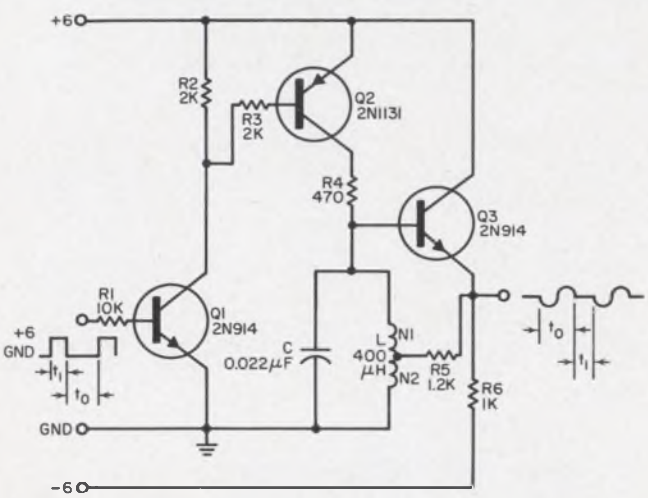
rise time is 0.2 μs to 0.3 μs. Capacitor *C1* is a speed-up capacitor and is unnecessary for slow circuits. Without *C1*, the output rise time into 20 ohms will be less than 5 μs and the output rise time into 1000 ohms will be less than 0.5 μs.

Jordan L. Miller, Design Engineer, Systems Div., EG&G, Inc., Bedford, Mass.

VOTE FOR 111

Pulsed oscillator reduces switching transients

The designer often requires a normally quiescent oscillator circuit that can be turned ON for the duration of a gating waveform. During the interval that it is ON, it should provide a sinusoid of fixed amplitude, frequency and phase with zero output before and after the gate. But usually when the oscillator is turned ON, a switching transient appears and makes the first few cycles



Modified Hartley oscillator delivers timing signals with minimum turn-on transient effects.

of the output waveform unsuitable for timing purposes.

A simple pulsed LC oscillator, similar to a Hartley circuit with minor modifications, can be used to generate the desired waveform (see schematic). Circuit operation is dependent on the state of transistor *Q2*. During interval t_1, transistor *Q1* is driven into saturation by the keying pulse. *Q2* is in turn driven into saturation by *Q1*. The initial current in L is thus current I:

$$I=(V_{cc}-V_{sat})/R=6-0.5/470=11.7 \text{ mA}.$$

At the end of interval t_1, transistors *Q1* and *Q2* are turned OFF and the tank circuit will begin to oscillate with initial amplitude:

$$E_{max}(0 \text{ to peak}) = (L/C)^{1/2}$$
$$= 11.7\times10^{-3}[(460\times10^{-6})/0.022\times10^{-6}]^{-1/2}$$
$$= 1.7 \text{ V},$$

and period:

$$t_0=2\pi\,(LC)^{1/2}=20\ \mu\text{s}.$$

If the oscillator transistor *Q3* were omitted, the voltage across the tank could be expected to decay because of the losses within the tank circuit. However, with the addition of positive feedback from the emitter of *Q3* to adjust loop gain to unity, a sinusoidal signal of constant amplitude can be obtained. The value of feedback resistor *R5* is adjusted experimentally, but it is possible to calculate an approximate value by making the following assumptions: Gain of emitter follower *Q3* is nominally unity; the coil is tapped at its midpoint; and the coupling between the two coil halves is perfect. Thus, the impedance seen looking into the tap is one-fourth of the resonant impedance of the tank circuit, or $R_{tap} = \frac{1}{4}\omega LQ$. For the loop gain to be unity, since the tank voltage is twice the voltage at the tap, $E_{out}/E_{tap}=2$. Therefore:

$$R_{tap}/(R_{tap}+R5)=1/2$$

or

$$R5=1/4\omega LQ.$$
$$R5(\text{theoretical})=1/4(2\pi)(50\times10^3)(460\times10^{-6})(35)$$
$$=1.32 \text{ k}\Omega.$$

Paul Berger, Design Engineer, CBS Laboratories, Stamford, Conn.

VOTE FOR 112

Analog multiplication and division circuits use log diodes

Diodes with exponential current-voltage relationships, together with packaged differential amplifiers, are the basic components of a pair of circuits—a multiplier and a divider. Aside from

Reducing a connector's length is one thing. Reducing its weight is another. Bendix Solder and Hermetic-Type "Pancake" connectors do both.

One thing you can say about Bendix® JT Pancake connectors: they reduce connector length by up to 50% and weight up to 60%, making them the smallest, lightest models available.

Equally impressive is the wide range of types we've got on hand, all ready to be delivered in rapid, off-the-shelf fashion. Among them are wall mount, box mount, jam nut, straight plug and 90° plug; nine different sizes; 34 different insert patterns; 16-, 20-, 22- and 24-contact sizes that will accept a wire range of 16 through 28 gage.

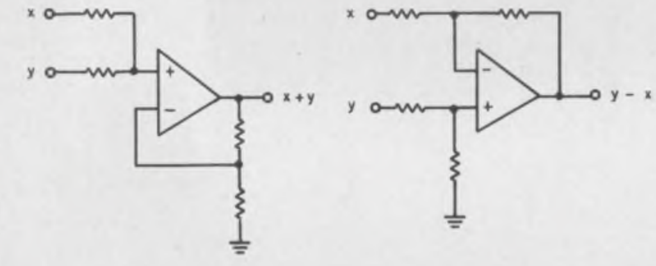
(You'll find most of these types available in our crimp-type JT Pancake connector line, too.)

What about performance? These lightweights have nine major design improvements. There are provisions for up to 128 contact pins, increased resistance to pin bending, greater contact retention, temperature capabilities to 392°F, and improved electrical characteristics through rigid, glass-filled epoxy inserts, to name a few. For complete information, write us in Sidney, New York.

Scintilla Division THE Bendix CORPORATION their simplicity, the circuits are fairly economical.

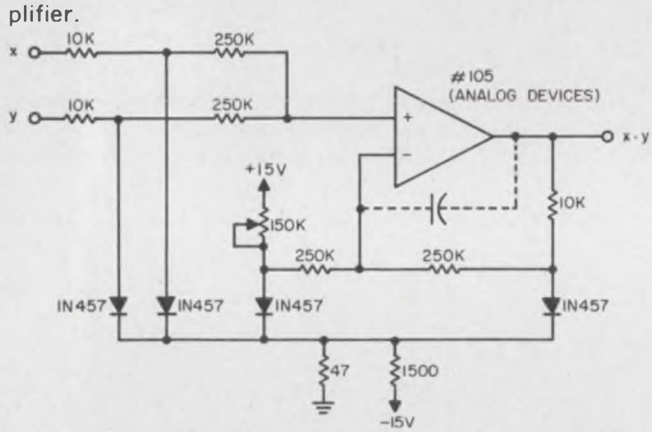
Similar to a slide rule, operations are performed by acting on the logarithms of the inputs and then obtaining an antilogarithm output. This involves use of a summing circuit for the multiplier and a subtracting circuit for the divider (Fig. 1). Since the two circuits are quite similar, only the multiplier is described here.

In Fig. 2, the analog inputs drive the diodes through the 10KΩ resistors to provide a logarithmic voltage at the inputs of a noninverting operational amplifier. If the output is assumed to be the final product, then the logarithm of it must match the logarithmic sum of the inputs. If the logarithm of the output is taken (in the same way that logarithms of the inputs are taken) and fed

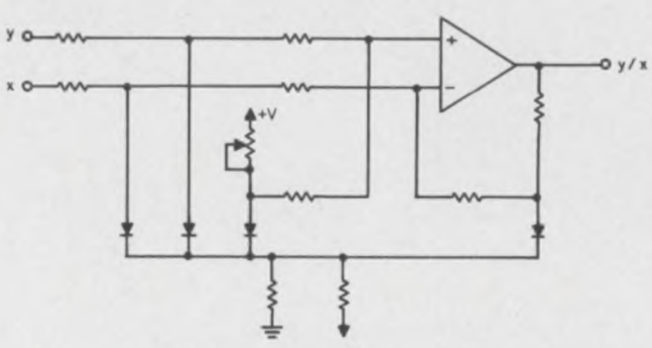


SUMMING CIRCUIT SUBTRACTING CIRCUIT

1. **Either sum or subtract circuit** can be affected by adjustment of the feedback network in the differential amplifier.



2. **Analog multiplier uses summing technique** for logarithmic inputs. By taking the logarithm of the output and comparing it with the input, the output goes to the true product.



3. **Divider circuit uses subtracting circuit** to compare logarithmic input and output and develop a divided output.

back to the differential input of the amplifier, the two values are matched, and the desired antilogarithm operation is accomplished.

In Fig. 2, the 47 ohm-1500 ohm resistor combination sets the diode bias and the 150-kilohm rheostat adjusts the reference for the feedback loop. Actual test results had a multiply accuracy of ±5% full scale for an input and output range of 0 to +10 volts. Fig. 3 is a schematic of the divider circuit implementation.

G. Richwell, Staff Engineer, Reflectone Electronics, Stamford, Conn.

VOTE FOR 113

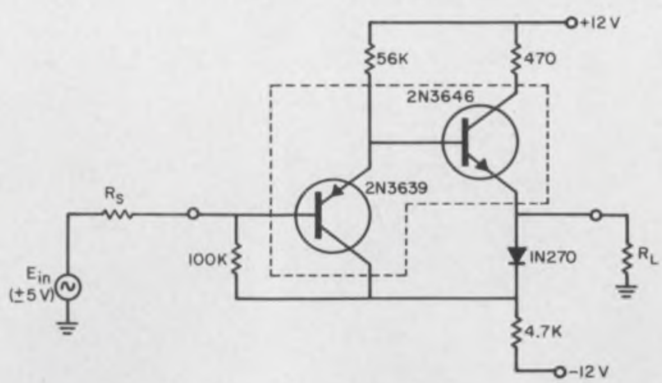
Complementary darlington: a leading emitter-follower

The simple conversion of a conventional darlington-type emitter-follower into a complementary unit brings about improved performance.

Among the benefits are:

- A lower offset voltage.
- A lower temperature coefficient.
- A lower input capacitance.
- A nulling capability.
- A higher frequency response.
- A better voltage-handling capability.

With conventional circuits in dc amplifier applications the input to output voltage level shift (offset voltage) is often troublesome. Typically, a strong temperature coefficient nominally of −4.0 mV/°C is the major cause of this. The complementary configuration (see schematic) reduces



Complementary darlington emitter-follower exhibits enhanced performance over conventional darlington. Offset voltage, temperature coefficient and input capacitance are all lower; frequency response is raised.

this temperature coefficient by a factor of 20 or better, thus nearly eliminating the offset.

Convenient bootstrapping of the input stage makes it possible for the input capacitance to be greatly reduced as well; only the output transistor need have a voltage rating greater than the peak-

to-peak signal voltage swing. Bootstrapping also allows the input current to be nulled out effectively. The input stage may then be operated at a relatively high emitter current for good frequency response. This is achieved without developing another temperature-variable offset voltage due to input base current responding to the external source impedance.

The germanium diode provides a level shift to bias the input. The bias resistor is selected to null the input current and produce approximately zero-volts output with the input open-circuited. The diode voltage reduces the bias with increasing temperature to compensate for the increase of β with temperature.

This circuit has a voltage gain of 0.992 and a current gain of 360 with a load of 5 kΩ and when $R_s = 0$. Its maximum offset is -0.2 V and its offset temperature coefficient is 160 μV/°C, under the same conditions.

When R_s = 1 MΩ, the current offset is +0.08 μA and the input impedance is 1.8 MΩ. This latter figure rises to 2.3 MΩ when the 5-kΩ load is open-circuited. Also, the offset temperature coefficient drops to only -4.0 nA/°C.

When a one-volt peak-to-peak signal is applied to the input, the circuit's rise time and band-width are 0.1 μs and 1.5 MHz, respectively. Note that the diode and 100 kΩ selected resistor components is the circuit are only necessary if high source-impedance generators are used at the input. With low R_s units, input current offset cancellation is not a requirement typically.

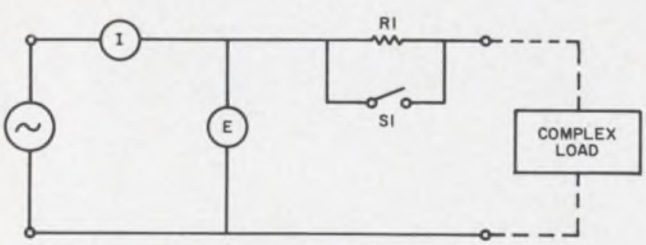
Robert W. Pargee, Senior Engineer, Electronic Engineering Co. Santa Ana, Calif.

VOTE FOR 114

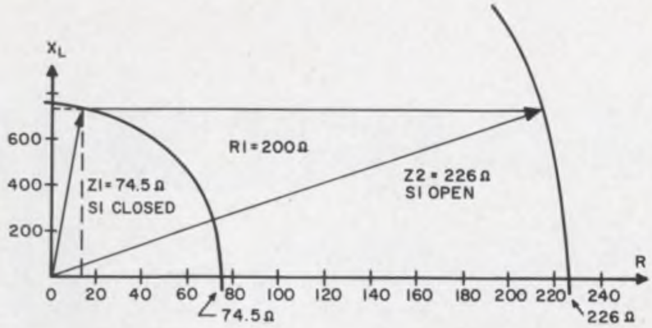
Impedance diagram simplifies complex load characterization

Here's a simple technique for determining the resistive and reactive terms of complex load. This method is quite useful when vendor data are not readily available or actual measurements have to be performed.

The test setup (Fig. 1) is simple to build and



1. **Switch (S1) allows impedance measurement** to be made with known resistance (R1) in and out of the circuit.



2. **Plotting the locus of the complex impedances** and the locus of the known real value (R1) yields a single solution from which the real and imaginary components of the unknown load may be determined.

uses any value of *R1* that is easily available. With *S1* closed, *Z1* (*E/I*) is measured and the value entered on the impedance diagram (Fig. 2). Then *S1* is opened, *Z2* is measured and its value entered on the impedance diagram. With a compass point at the origin, draw an arc through *Z1* and one through *Z2*. The only difference between *Z1* and *Z2* is the value of *R1*, and *R1* is a real and known value. As a result, there is only one place on the diagram where a line parallel to the origin and of a known length (*R1*) can fit between the two arcs. The point where this line intersects the arc of *Z1* will determine the value of *R* and *X* of the unknown load, and may be scaled from the diagram.

In the diagram given, a 200-ohm resistor is used for *R1* and the load is a 26-V, 400-Hz synchro motor. The voltage and current measurements yield a value of *Z1* = 74.5 ohms and *Z2* = 226 ohms. The calculated reactance is 73.5 ohms and the resistance is 13.5 ohms.

J. L. Earl, Instrumentation Engineer, Lockheed Missiles & Space Co., Sunnyvale, Calif.

VOTE FOR 115

Two IFD Winners for July 5, 1966

The voting by our readers resulted in a tie beween two Ideas published in the July 5 issue. Winners were:

E. K. Howell, Applications Engineer, General Electric Co., Auburn, N. Y. for his Idea, "Tandem dimmer uses Triac power controllers."

Frank A. Memmo, Sr. Project Engineer, EIMAC, Div. of Varian Assoc., San Carlos, Calif. for his Idea, "Phase-controlled oscillator has electronic frequency-tuning."

Both authors will receive the $50 Most Valuable of Issue Award.

Cast Your Vote for the Best Idea in this Issue.

IFD Winner for July 19, 1966

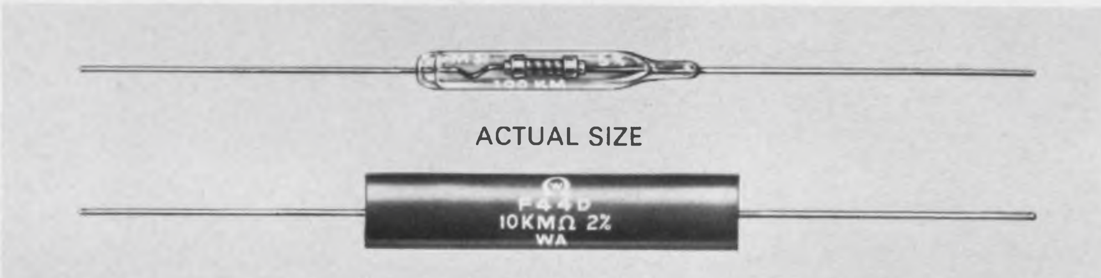
J. L. Divilbiss, Sr. Research Engineer, Dept. of Computer Science, Univ. of Ill., Urbana, Ill.

His Idea, "Diode tester offers no risk to components," has been voted the $50 Most Valuable of Issue Award.

Cast Your Vote for the Best Idea in this Issue.

Welwyn, major producer of all types of resistance products

(and recent recipient of Lockheed Zero Defects Award)



Now offers new millimetric* tin oxide film ultra high value and high voltage resistors with stability heretofore unattainable

These new products are the latest result of Welwyn's many years of experience in the manufacture and supply of High Voltage/High Value resistors. Produced by an entirely new process and incorporating films many orders of magnitude thicker, their improvement in performance is impressive, and particularly so if compared with other types now available.

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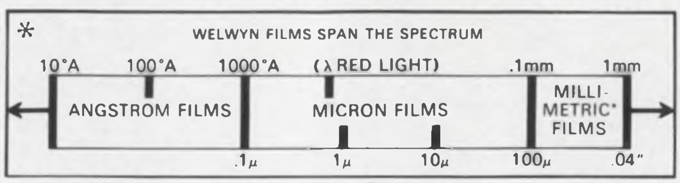

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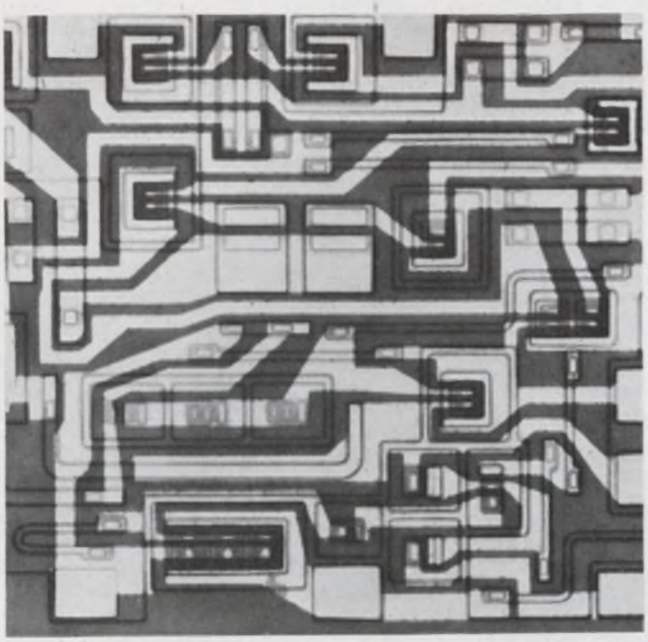
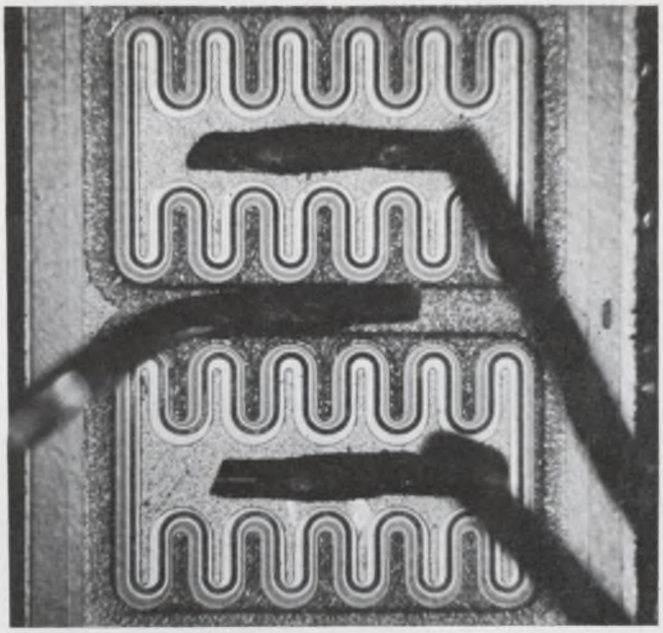
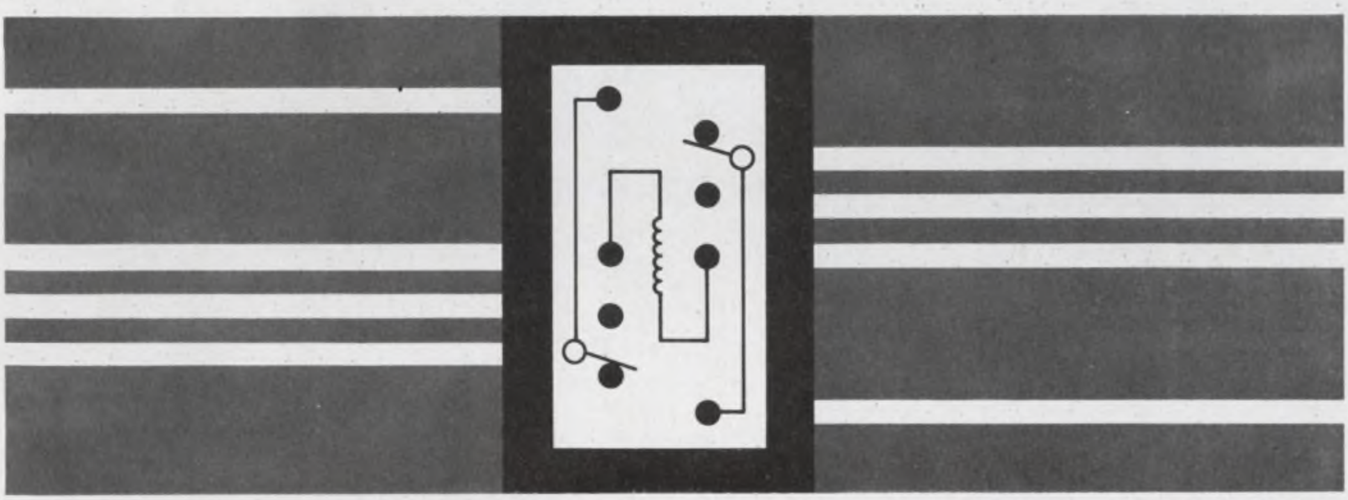


Monolithic sense amplifier has 40-ns response, 50- and 80-ns recoveries. Page 116



Power planars use "field plate," nichrome resistors to boost RF performance. Page 108



A relay in a flat pack? This 1/4-A, 28-V dpdt magnetic relay fits snugly in its 8-lead JEDEC TO-87 flat pack, mounts neatly on low-profile (0.1-in.) printed circuit cards. Page 126

Also in this section:

'Field plate,' nichrome resistors push planar performance

Three innovations have been made in the design of high-power RF silicon planar transistors. They could extend peak voltage and frequency capabilities to 1 kV and 1 GHz, according to Fairchild Semiconductor, manufacturer of the devices.

The innovations are as follows:

- A "field plate," which gives the npn type SE7020 a 300-V breakdown.
- Nichrome thin-film resistors in series with the emitter, which give the npn 2N4115 and 4116 a 30-W dc safe area output with 5-A, 80-V and 80-MHz capabilities.
- Multiple emitters with nichrome resistors, which enable the FT502 power transistor to offer 25 W at 150 MHz.

High-voltage breakdown in the planar npn SE7020 is accomplished by using the "field plate" (Fig. 1). This is base metallization, extended over the collector-base junction, which serves to distribute the field at that point. The technique avoids field concentration and possible subsequent breakdown. (Such failures formerly limited planar devices to about 200 V). To add to the stability, channels are completely eliminated by electrically connecting the equipotential ring to the collector. Packaging of the device is in a TO-66 can.

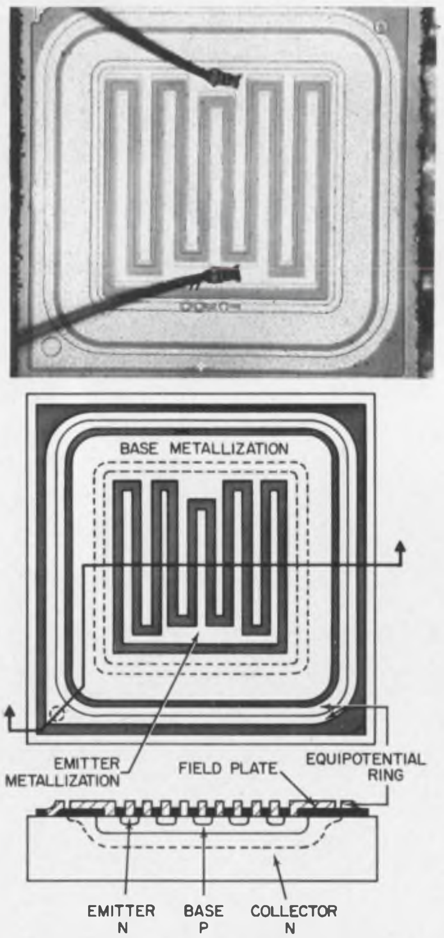
The deposition of nichrome thin-film resistors in series with the emitters (Fig. 2) during planar epitaxial processing results in the high-power (30-W dc safe area) output of the 2N4115 and 4116. Power transistors, in general, can be considered as several smaller equivalent transistors in parallel. With the nichrome resistors, when one of these equivalent transistors begins to draw enough current to cause overheating, the excess current is diverted by negative feedback to an adjacent parallel transistor. This diversion delays secondary breakdown caused by excess current concentration ("current hogging") and ultimate transistor failure. The result is a high-voltage (80-V BV_{CEO}), high-current (5-A) RF transistor. Beta is 40 to 120 at 2 A and gain-bandwidth product is 70 MHz (4115), and 100 to 300 at 2 A with an 80-MHz gain-bandwidth (4116). Packaging is in the isolated collector TO-59. Pnp complements are available.

Multiple emitters in conjunction with nichrome resistors on a single silicon chip are used to extend high-frequency performance and safe operating areas of the high current FT502. (Fairchild is shooting for a 1-GHz, 5-W device). The FT502, capable of 25 W at 150 MHz, is currently available. The device is packaged in a TO-66 can.

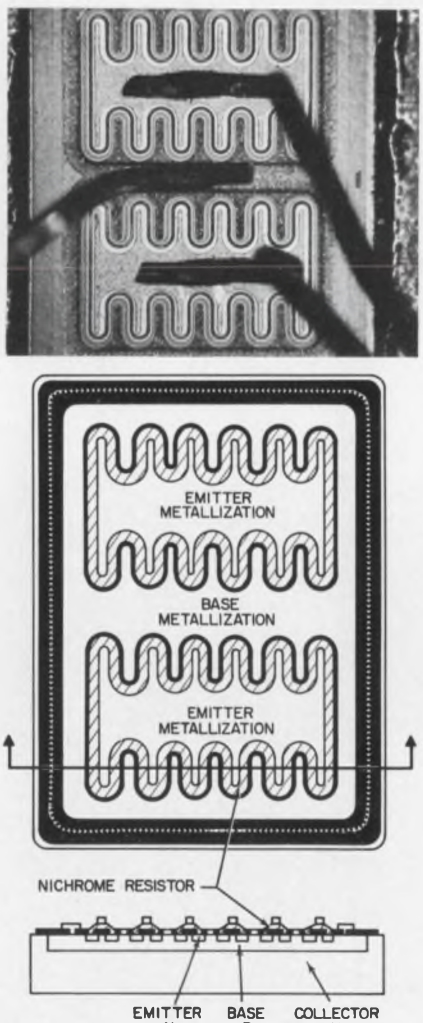
The transistors may be used in RF amplifiers, servo amplifiers, converters, inverters, and regulators, as well as two-way mobile radio telephones, marine radios, single-sideband transmitters and citizens band and portable communications systems. A secondary advantage, excellent resistance to radiation, makes the devices attractive for satellite and missile applications.

P&A: $24 (2N4115), $36 (2N4116), $0.80 (SE7020), (100-999); stock. FT502; December. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-5011.

Circle No. 153



1. **"Field plate"** (base metallization) is extended over collector-base junction to distribute the field and avoid concentration. Channels are eliminated by electrically connecting the equipotential ring to the collector, thus adding to stability. The result is a device with 300-V breakdown.



2. **Thin-film nichrome resistors** in series with emitters eliminate hot spots and delay breakdown caused by "current hogging."

Six ratings from 1 to 3 amps...

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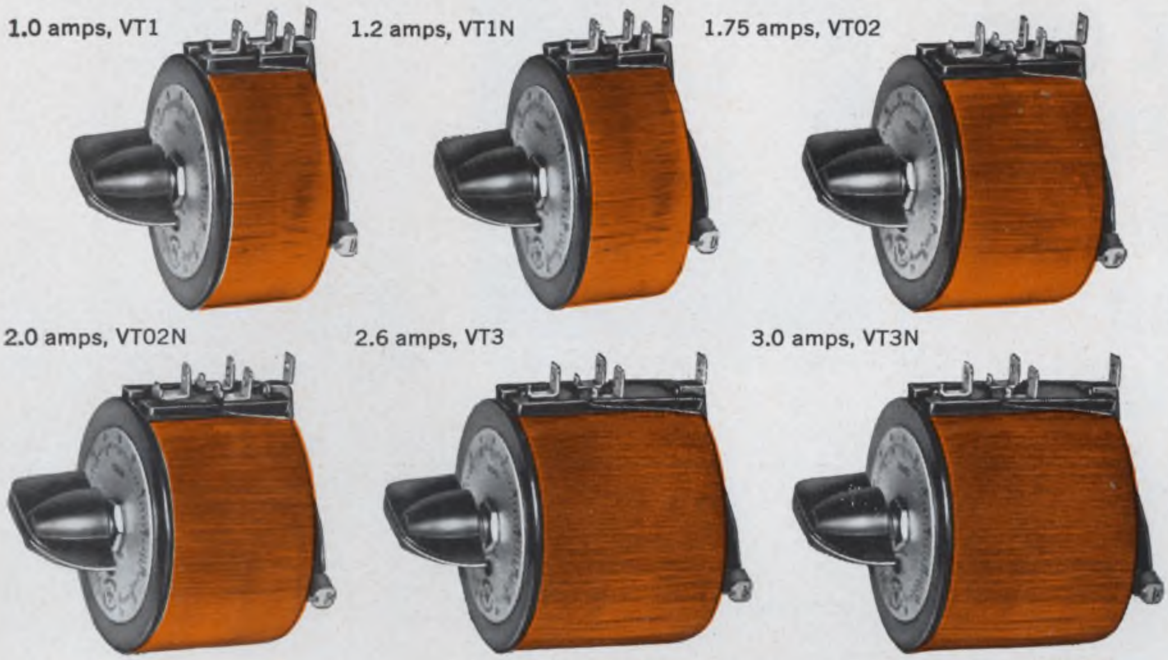

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Adjustable shaft (extends from either end) for mounting convenience or for operating auxiliary controls.

Multi-purpose terminals for soldering, quick connectors or screws.

Replaceable brushes with rapid, snap-in design and husky heat sink.

Same silhouette and mounting arrangement for all six ratings allowing standardization of panel treatment.

Model variations include fixed and portable enclosures, ganged assemblies, and motor-driven assemblies.

The Industry's Fastest Growing Line of Variable Transformers . . . 1 to 25 Amps, Hundreds of Stock and Made-To-Order Models. Write for Catalog 500.

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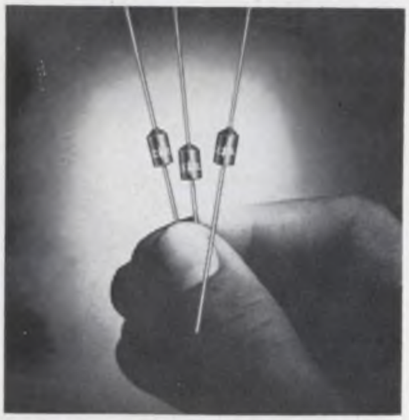
ON READER-SERVICE CARD CIRCLE 52



Zener voltage regulator

A line of molded zener voltage regulators in the DO-27 case style is rated from 3.3 to 15 V with maximum current ratings from 300 mA to 60 mA. The 1-W zeners are designed as regulators and protection devices for control, regulating and monitoring functions. Industrial applications include process control, instrumentation, switching, measurement, modulation and energy conversion, generation and transmission.

P&A: $0.60 to 1.10 (100 to 999); stock to 6 wks. International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281

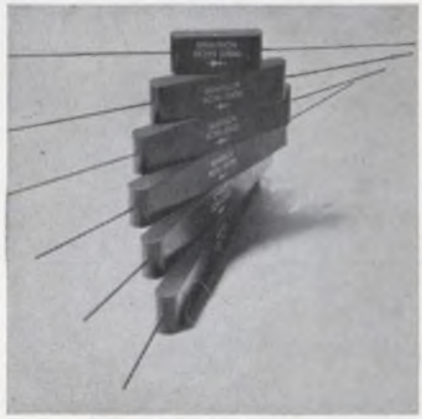
Circle No. 154

Germanium transistors

Germanium pnp power transistor series 2N2869 and 2N2870 are replacements for 2N301 and 2N301A types. Packaged in a TO-3 case, they are capable of 55-V collector-to-emitter operation and 80-V collector-to-base operation. The devices have low saturation voltages and usable gain at 10 A collector current.

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Circle No. 155

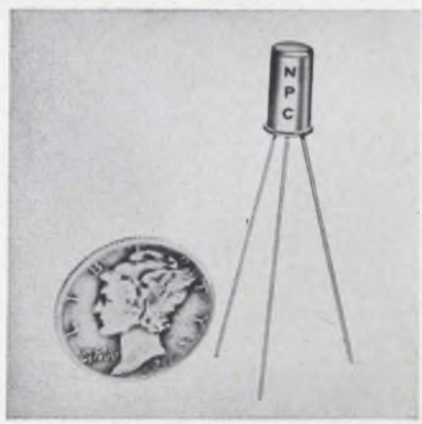


Rectifiers have 15-kV PIV

High-voltage, coax lead mounting silicon rectifiers have PIV ratings of 2500, 5000, 7500, 10,000, 12,500 and 15,000 V. The units are rated at 2 A in free air and 4 A in oil. The devices feature low forward drop, low leakage (10 μA at PIV and 25°C) and operating and storage temperatures of −55 to 175°C. Internally, solid double heat sink junctions welded together eliminate the use of solders. The package is 0.375 inches by 0.687 in. The length will vary with the PIV rating from 1.5 to 6.5 in.

Semtech Corp., 652 Mitchell Rd., Newbury Park, Calif. Phone: (213) 628-5392.

Circle No. 156

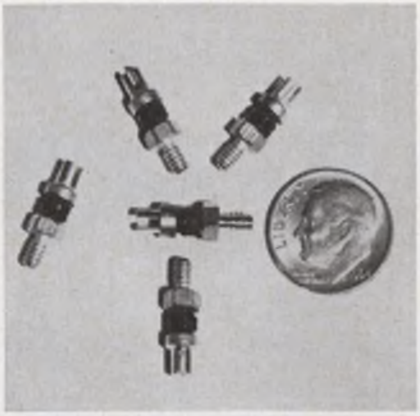


Germanium transistors

Packaged in a TO-1 case, these npn geranium transistors exhibit very good beta linearity and are suitable for Class B push-pull applications. A pair of either the 2N2430 or 2N2431 jointly used in transformerless circuitry give complementary symmetry.

Nucleonic Products Co. Inc., 3133 E. 12th St., Los Angeles, Calif. Phone: (213) 268-3464.

Circle No. 157



9-A stud rectifiers

Offering controlled avalanche characteristics, this stud mount rectifier has a current rating of 9 A and PIV of 400 V max. Surge rating is 150 A max for 1 cycle. Recovery times of 250 ns min permit operation at frequencies up to 40 kHz square wave or greater for sine wave. The unit is monolithic, voidless and whisker-free and is bonded to two terminal pins.

P&A: $8.50 to $22; stock. Unitrode Corp., 580 Pleasant St., Watertown, Mass. Phone: (617) 926-0404.

Circle No. 158

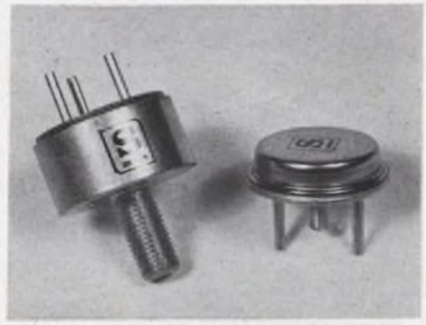
5-A power transistors

Collector-to-emitter sustaining voltages of up to 200 V are available with this line of 5-A npn planar power transistors. The units can dissipate 20 W at 100°C case temperature. Collector current is 1 A and V_{CE} (sat) is 0.50 V max. Each of the two gain (h_{FE}) families (20 to 60 and 40 to 120) is available with a V_{CE} (sus) of 125, 150, 175 or 200 V.

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Circle No. 159

SEMICONDUCTORS



65-A high-gain transistor

High-current germanium power transistors offer a higher efficiency than any other general purpose transistor now on the market. The SDT1860 and SDT1960 series are capable of maximum efficiency because of their low collector saturation voltage (0.3 V), low input voltage and high current gain. The transistors are available in the TO-36 can as well as in a double-ended package which offers less restrictive hook-up of large conductors. As an option, both packages come in flattened or pierced terminals, eliminating the need for an additional terminal connector. A terminal hole size of 0.12-in. x 0.19-in. can be provided. H_{FE} exceeds 20 at a full 65-A collector current. The devices are suited for motor speed control, converters, and other switching and amplifier applications.

Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Circle No. 160

50-cent plastic FETs for AF amplifiers, switching

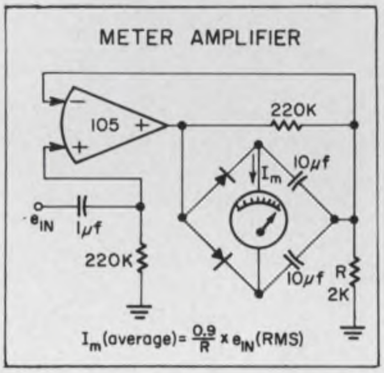
Three n-channel, one-piece molded plastic junction FETs (types MPF-103, 104 and 105) are designed for general purpose audio amplifier and switching applications in industrial and consumer equipment. Forward transfer admittances are 3000, 4000 and 4500 μmho. Gate-to-source cutoff voltages are −6, −7, and −8 Vdc. Gate-to-source breakdown voltage is −25 Vdc, input capacitance is 7 pF, output admittance is 50 μmho and reverse transfer capacitance is 3 pF.

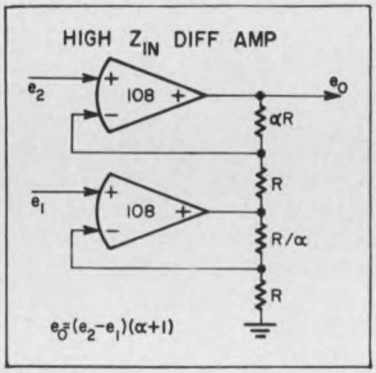
P&A: $0.50 (1000-up); stock. Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix, Phone: (602) 273-6900.

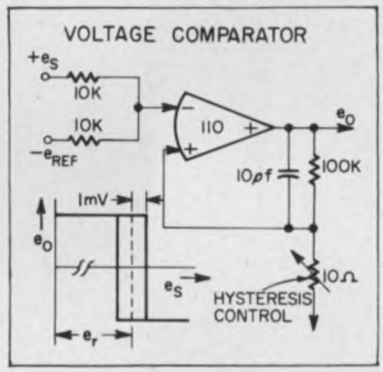
Circle No. 161

OPERATIONAL AMPLIFIERS

Broad line of economy amplifiers from $19 to $58 optimizes performance-versus-cost for vast range of analog circuits.







Model	Voltage Gain Min.	Output Rating	Current Drift* (each input)	Current Drift* (Diff.)	Bandwidth	Price (1-9)
105—General Purpose, Low Cost	30,000	±10V @ 2.2ma	1.5na/°C	0.5na/°C	1.5mHz	$19.
106—High Gain	150,000	+10V @ 5ma	1.5na/°C	0.5na/°C	1.5mHz	$26.
108—Low Current Drift	50,000	±10V @ 2.5ma	0.3na/°C	0.1na/°C	0.5mHz	$35.
109—High Output Current	150,000	±10V @ 20ma	1.5na/°C	0.5na/°C	1.5mHz	$55.
110—Wideband 100V/μS Slewing	50,000	±10V @ 20ma	1na/°C	0.3na/°C	20mHz	$58.
150—±2.7V Battery Powered	50,000	±1.5 @ 2.5ma	1.5na/°C	0.5na/°C	1.5mHz	$30.
160—High Voltage	150,000	±20V @ 2.5ma	1.5na/°C	0.5na/°C	1.5mHz	$45.

*Maximum drift from −25°C to +85°C. Model A:20μV/°C, Model B:10μV/°C over same range.

Mark reader service card to receive Economy Line catalog giving full details on 11 different low-cost amplifiers. Remember that amplifiers can be specially selected, or modified at low cost, to meet your exact requirements. Why not request one for evaluation in your circuit?

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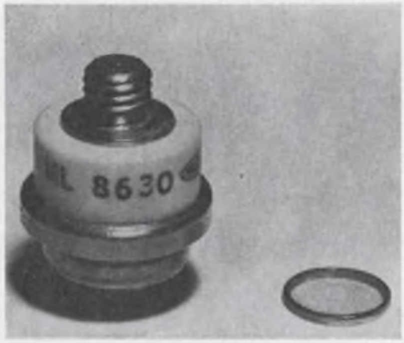
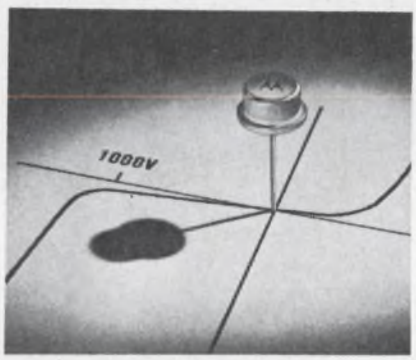


Planar triode tubes

With a thin 24 carat gold coating on all exposed metallic surfaces, this planar triode tube series has applications in DME and transponder equipment. Inside the tube a very thin gold coating on the 0.0008-in. diameter tungsten wire grid, spaced with more than 150 turn/in., suppresses electron emission from the grid. The grid operates at temperatures above 1500°F without deformation.

Engelhard Industries Inc., 113 Astor St., Newark, N. J. Phone: (201) 242-2700. *Circle No. 162*



Silicon rectifiers

This series of silicon rectifiers has an average forward voltage of 0.6 V at a forward current of 25 A. PIV and average reverse current is 500 V and 3 mA for type MR327, 600 V and 2.5 mA for type MR 328, 800 V and 2 mA for type MR330 and 1 kV and 1.5 mA for type MR331. Failure rate of the series is 0.005%/1000 hours. The units are designed for use as a free-wheeling diode in inductive surge suppressor circuits and in 440-Vac circuits where transient protection has been designed in.

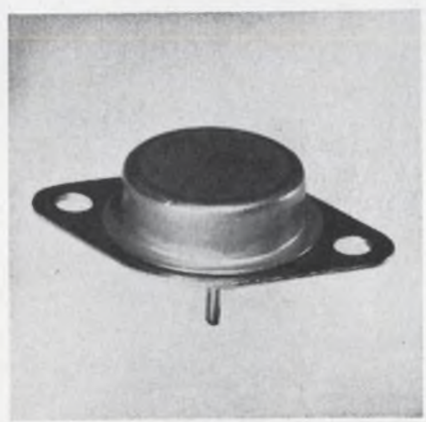
Price: $1.60 to $6.50. Motorola Semiconductor Products Inc., P. O. Box 955, Phoenix, Ariz. Phone: (602) 273-6900. *Circle No. 163*

Silicon switching FETs

The CM640 series of silicon epitaxial junction switching FETs feature R_{ON} of 25 Ω, I_{OFF} of 0.4 nA, V_P from 1.5 V and C_{DG} of 5.0 pF. The package is an isolated 3-lead TO-18. Typical applications include digital-to-analog converters, multiplexers and chopper-stabilized amplifiers.

P&A: from $8.80; stock. Teledyne Inc., Crystalonics Div., 147 Sherman, Cambridge, Mass. Phone: (617) 491-1670.

Circle No. 164



Silicon power transistor

A V_{CEO} (sus) of 325 V and V_{CER} of 400 V is provided by this npn silicon power transistor. Applications include high voltage, wide band amplifiers, relay drivers, waveform amplifiers, converters and inverters. H_{FE} is greater than 30 at collector current of 1 A and a V_{CE} of 5 V. The unit has an h_{FE} of 10 min at 2.5-A collector current and a V_{CE} of 5 V.

Industro Transistor Corp., 35-10 36th Ave., Long Island City, N. Y. Phone: (212) 392-8000.

Circle No. 165

CTC

trims size, cuts cost and eliminates temperature compensating circuits

−100 0 +100

New IRC metal film resistors with any specified TC between −100 and +100ppm

Controlled Temperature Characteristic—a new IRC line of high-stability precision metal film resistors—is made by a technology so refined that TC can be controlled to any desired point between −100 and +100ppm, ±5ppm.

In analog computers, CTC resistors offer fast rise times, precision and stability over a wide temperature range. They can simplify or completely eliminate temperature compensating devices in a wide range of delicate sensing instruments.

Inductance and capacitance are negligible. CTC resistors replace wire-wound types with space and cost savings, and are far more reliable . . . even at higher resistance values. Write for complete data and prices. IRC, Inc., 401 North Broad Street, Philadelphia, Pa. 19108.

CAPSULE SPECIFICATIONS

SIZE	RN65
TC	Any TC between −100 and +100ppm, ±5ppm
TEMP. SPAN	Any 50°C increment between −55°C and 165°C
RESISTANCE	50Ω to 360KΩ
POWER	¼-W @ 125°C, ½-W @ 70°C
STD. TOLERANCES	0.1, 0.05, 0.025%

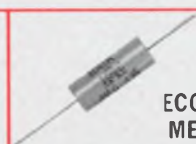
INDUSTRY'S LARGEST SELECTION OF METAL FILM RESISTORS

ASSURED RELIABILITY METAL FILM

An industry first. 0.1, 0.01 or 0.001% levels. 1/20 to 2 watts. 20 ohms to 1 meg. ±25, 50 and 100ppm. 0.25, 0.5 and 1% tolerances.

HIGH STABILITY METAL FILM

Molded and coated types, including microminiature, 1/10 to 2 watts. 30 ohms to 10 meg. 8 TC's from ±25ppm. Tolerances from 0.05%.



ECONOMICAL METAL FILM

Molded and coated types for MIL-R-10509. TC guaranteed to within 100ppm. 1/10 to 2 watts, 10 ohms to 10 meg. 0.5 and 1% tolerances.

DEPOSITED CARBON FILM

Molded types from ⅛ to 2 watts, coated types from ½ to 2 watts. 10 ohms to 1 meg. 0.5, 1 and 2% tolerances. MIL-R-10509.

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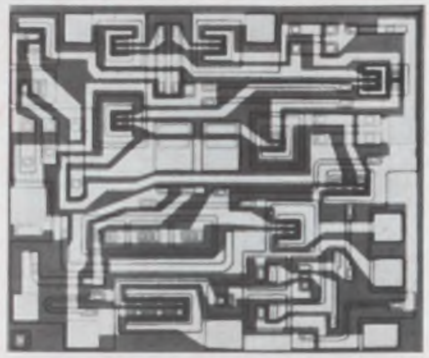

Sense amplifier has fast response, recovery

Consisting of a wideband, two-stage, differential amplifier, a dc restoration circuit and a DTL output gate, the MC1540 monolithic sense amplifier is designed to detect bipolar differential signals originating from core memories with cycle times as low as 0.5 ms and to translate these signals into saturated logic output signals. Response time is 40 ns and recovery time is 50 ns with a 2-V common-mode signal and 80 ns with a 400-V differential signal.

The dc restoration circuit has facilities to externally adjust the input threshold level from 10 to 25 mV without changing the width of the transition region. When pin 6 of the 10-pin TO-5 package is held to 6 V, the nominal threshold is 17 mV. Threshold drift is 10 μV/°C. The DTL output gate makes strobing the sense amplifier possible from any saturated logic family.

P&A: $24.50 (over 100); stock. Motorola Semiconductor Products, P. O. Box 955, Phoenix, Ariz. Phone: (602) 273-6900.

Circle No. 166

14-lead connector

This device is designed for testing, breadboarding and production packaging of plug-in devices having up to 14 leads. The connector has 14 positions consisting of two rows of seven lead sockets on 0.1-in. centers spaced 0.3-in. apart. Socket locations are numbered on the top and on the bottom of the connector and one corner is chamfered for indexing of devices.

Texas Instruments Inc., 34 Forest St., Attleboro, Mass. Phone: (617) 222-2800.

Circle No. 167

We're normally a hard-nosed, unsentimental bunch at CMC, dedicated to giving the other two major makers of electronic counters (Hewlett-Packard and Beckman) a run for their money. So you wouldn't think we'd have time for motherhood or advancing the counter art. **But,** we've scored on all three with our new 600-Series. (1) It's the first all-silicon solid state counter. (2) We're the first of the big three to use the advanced "Mother-Board" technique. So we've cut size, weight, and components while increasing reliability and ease-of-maintenance. (3) Operating temperatures from −30° to +75°C are available. (Other folks we know strain to claim −25° to +65°C). Model 607 provides a frequency range of 0 to 5 Mc and period measurement of 0 to 1 Mc. Other models have readout from 2 cps to 2.5 Mc. That's eight times faster than any competitive counter at the price. All this, and a price that's competitive with ordinary germanium counters. **Something free!** We give a glorious Crusading Engineers' medal to engineers who have the courage to compare **everyone's** performance specs before buying a counter. Get yours by writing today for our new stimulating technical catalog. It's free, too. And your Mother will be so proud of your shiny medal.

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ON READER-SERVICE CARD CIRCLE 60

Parasitic-free DTL ICs

Eight DTL ICs using dielectric isolation offer parasitic-free operation and a wide temperature range. Two new dual pulse triggered binary ICs, intended for use in high-speed low-power digital systems, will operate in binary counters at speeds exceeding 20 MHz. Both are capable of driving large capacitive loads. The RD-221 has a fan-out of 10 and the RD-321 has a fan-out of 5. Both dissipate 24 mW with a noise immunity of 800 mV. Input and output voltage is 6 V, V_{cc} is 8 V and output current is ± 100 mA.

Four hex inverters are also offered. The RD-223 is a high-voltage unit with a typical propagation delay of 15 ns. Power dissipation is 10 mW and noise immunity is 800 mV. Output breakdown is 40 V. The RD-220, RD-320 and RD-520 offer a choice of either 5 or 8 fan-outs.

Completing the line are two 4-input logic gate expanders, one covering -55 to 125°C and the other 0 to 75°C. Other maximum ratings for the logic gate expanders are the same: input is 6 V, input current is -20 mA and reverse current is 15 mA.

Radiation Inc., Melbourne, Fla. Phone: (305) 723-1511.

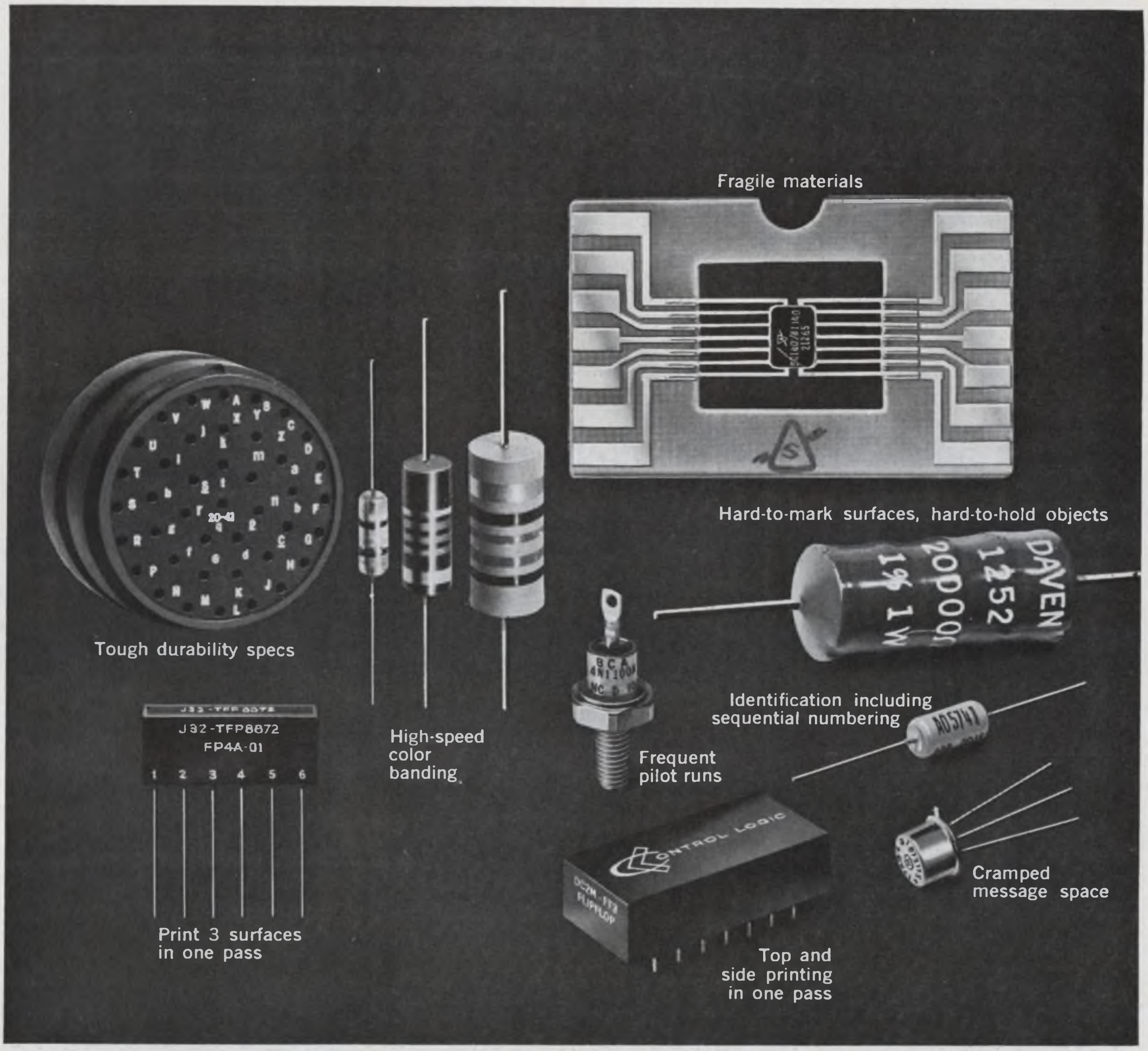
Circle No. 168

IR-emitting diodes

Optical immersion and a built-in miniature parabolic reflector enable this IR-emitting GaAs diode to provide up to 40 mW continuous output at 0.92 microns in a 15° cone when operated at room temperature with 2 A dc input. Conversion efficiencies are greater than 1%. With 12-A/10-μs pulses and 10-KHz rep rate, output is typically 130 mW. Operating threshold current is less than 2 mA.

Price: $135 (1 to 9). Microelectronics Division, Philco Corp., 2920 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-2966.

Circle No. 169


Fragile materials
Hard-to-mark surfaces, hard-to-hold objects
DAVEN
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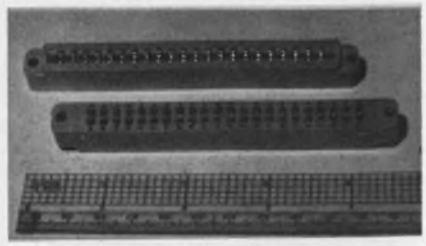
20D00
1% 1W
Tough durability specs
J32-TFP8872
FP4A-01
1 2 3 4 5 6
High-speed
color
banding
Frequent
pilot runs
Identification including
sequential numbering
CONTROL LOGIC
Cramped
message space
Print 3 surfaces
in one pass
Top and
side printing
in one pass

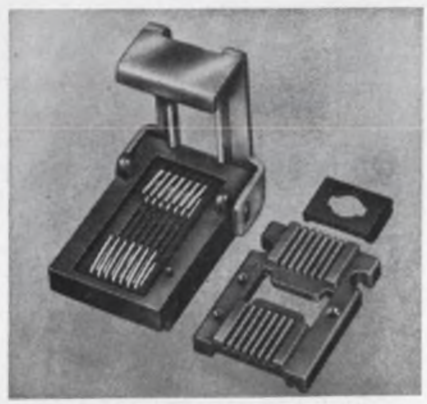


Taper pin receptacle

Dual-contact, PC board receptacles accept taper pin terminations. An 18-contact version is 3-21/32-in. long, 7/16-in. wide and weighs 1.2 oz. It accepts boards ranging from 0.054- to 0.071-in. thick with contact spacing of 0.156-in. The dual contacts are heat-treated beryllium copper, gold flashed over silver plate and reinforced by a stainless steel ring on the taper pin side. The body is glass-fiber-filled diallyl phthalate. Contact current rating is 5 A, average breakdown voltage between contacts is 1800 Vac and operating voltage is 500 Vac.

U.S. Components Inc., 1320 Zerega Ave., Bronx, N. Y. Phone: (212) 824-1600.

Circle No. 211

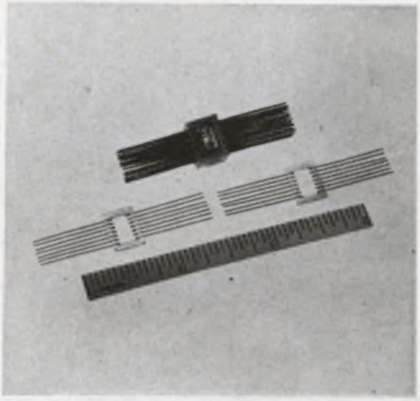


14-lead contactor

For use in production, aging and breadboarding of carrier-held 14-lead flat-pack ICs, this contactor features one-hand operation with a push-pull steel latch. Polarization pins assure correct orientation of the carrier in the contactor. With a body molded of polysulfone, the unit can operate at temperatures from −65 to 150°C. Contacts are beryllium copper, hard gold over nickel plated. Contact resistance is less than 0.01 Ω.

P&A: $1.75 to $5; stock to 2 wks. Barnes Development Co., Lansdowne, Pa. Phone: (215) 622-1523.

Circle No. 212

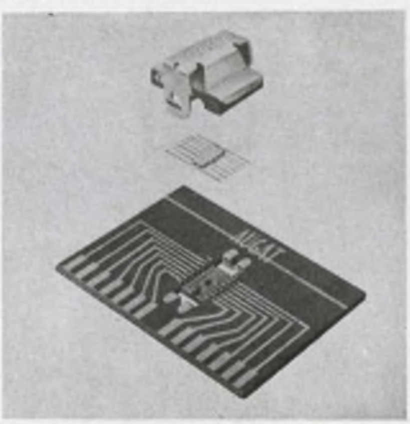


Flat-pack connector

The leads and hermetic seal of IC flat-packs are protected on this flat-pack mounting frame connector during computer assembly. The flat-pack connector is tailored for 14-lead 1/8- x 1/4-in. IC flat-packs. A frame-support surrounds the flat-pack with a rigid molded plastic assembly. Connections to the flat-pack leads are provided within the connector frame by welds onto the flattened ends of nickel molded-in wires.

Hughes Aircraft Co., Electronic Products Div., 500 Superior Ave., Newport Beach, Calif. Phone: (714) 548-0671.

Circle No. 213

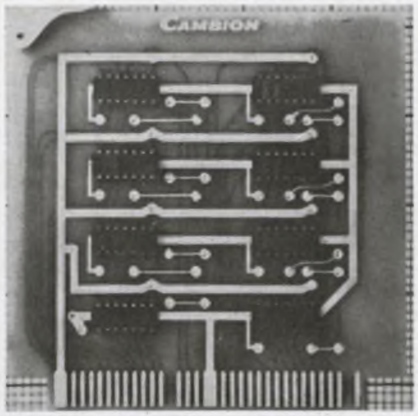


IC test socket

The snap-action cover of this test socket provides positive contact and eliminates soldering or welding IC leads. Leads are not damaged in loading. The unit accepts any pack up to 1/4 x 3/8 in. with up to 14 leads. Test sockets are also available for dual in-line packages and TO-5 cans.

P&A: \$0.95 to \$2.50; 1 to 2 wks. Augat Inc., 33 Perry Ave., Attleboro, Mass. Phone: (617) 222-2202.

Circle No. 214



DTL shift registers

General pupose shift registers are offered in 19 different logic configurations, including one 8-stage, two 4-stage, three 3-stage and four 2-stage combinations. The registers may be used for a variety of computer shifting requirements, including ring counters and serial operating systems. They incorporate J-K flip-flops in each stage and use DTL ICs throughout. Shift rates are up to 5 MHz. The in-line packages are assembled on glass epoxy boards printed on both sides. The boards are spray-etched and wavesoldered. All conductors are 0.02-in. wide with 0.02-in minimum spacing. Power conductors are 0.1-in. wide with 0.021-in. minimum spacing. Input/output connections are made via a 70-pin connector.

P&A: from \$45.05 (10 to 49); stock. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. Phone: (617) 876-2800.

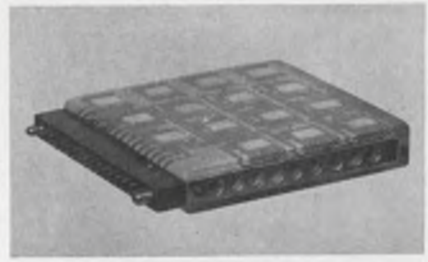
Circle No. 215

Thick film resistors

Thick film resistor/conductor modules for hybrid integrated circuitry are offered in values from 10 Ω to 10 MΩ, tolerances from $\pm 20\%$ to $\pm 1\%$ and temperature coefficients to 150 ppm/°C. The 96 alumina substrates are screen printed and fired at temperatures up to 1000°C. Resistors are hermetically sealed in fused glass and conductors are solderable and weldable. Wattage ratings are to 20 W/in.^{2} with external heat sink.

P&A: about \$1; 3 to 6 wks. Dictograph Products Inc., Danbury, Conn. Phone: (203) 744-1900.

Circle No. 216



Flat pack interconnect

Multilayer interconnect modules for IC flat packs eliminate through holes for layer-to-layer connections. The circuitry is flame-sprayed through a photoetched mask. Layer-to-layer interfaces can not be detected visually or electrically. The aluminum substrate can be utilized as a heat sink or, due to the method of application of the insulation layers, as a ground or voltage plane. The remaining exposed surface can either be a complete level of circuitry or serve as copper pads for IC mounting. Mounting can be accomplished by conventional or resistance soldering or welding. With minor design changes, the board can be fabricated to accept through hole mounting of dual in-line packages.

Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N. Y. Phone: (914) 359-5050.

Circle No. 217

Breadboarding kits

Breadboarding kits to introduce designers to ICs contain a variety of basic circuits and breadboarding sockets. Sample diagrams for such applications as converters, counters, adders and amplifiers are given. The kits cover TTL and DTL digital circuits and operational amplifiers. Two of the kits contain seven and eight ICs each, plus four to six breadboard sockets. The third kit, for amplifier applications, contains four amplifier circuits and two sockets.

Price: $49.50. Texas Instruments Inc., 13500 N. Central Expressway, Dallas, Texas. Phone: (214) 235-3111.

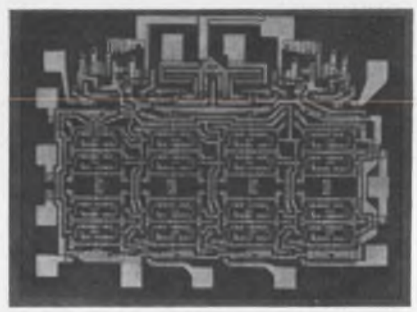
Circle No. 218

3- and 4-lead test sockets

Series MS sockets accept stud, TO-5 and other style packages having 3 or 4 leads on a 0.2-in. diameter circle. Molded of Teflon FEP or polysulfone, their flanged bodies are designed for press mounting in 7/16-in. holes. The sockets have pyramid tops, polarization indices and polarization notches along the body. Both units have tapered lead entrances. Contacts and terminals are beryllium copper, spring tempered and hard-gold over nickel plated. Terminals are tubular and pierced at the ends.

P&A: $0.80 to $2.25; stock. Barnes Development Co., 24 N. Lansdowne Ave., Lansdowne, Pa. Phone: (215) 622-1525.

Circle No. 219



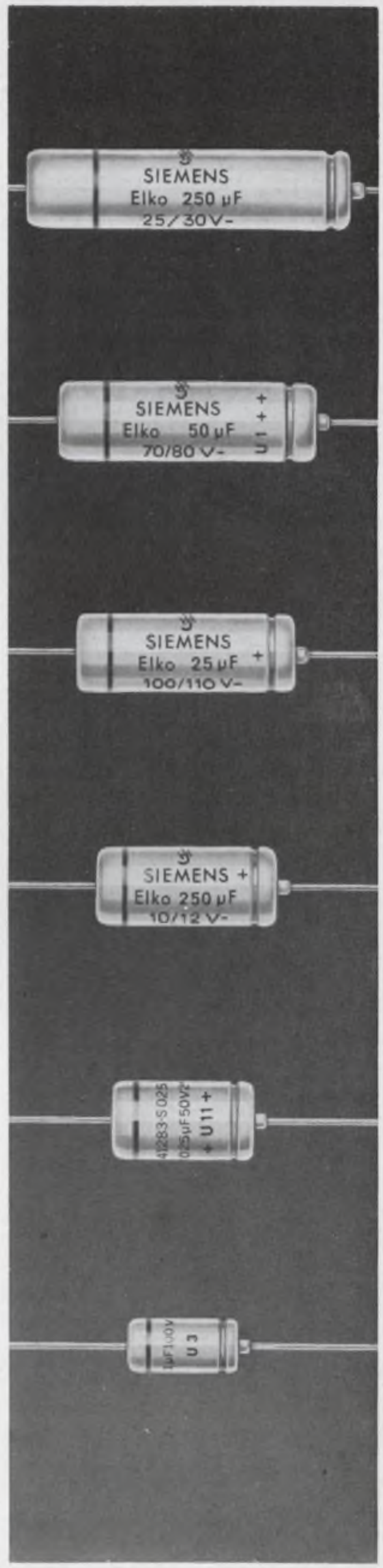
16-bit memory

Temperature ratings on this 16-bit, 10-MHz TTL memory have been extended to cover −55 to 125°C. The monolithic elements consist of 16 two-transistor flip-flops arranged in a 4 x 4 matrix providing information storage. Two write and two sense amplifiers are also built into the element. Both data and data complement are available at the sensing outputs, which can be paralleled for larger arrays. Delay between addressing and read or write is 20 ns. The memories are packaged in a 14-lead flat pack or dual in-line plug-in.

Transitron Electronic Corp., 168 Albion St., Wakefield, Mass. Phone: (617) 245-4500.

Circle No. 220

SIEMENS



ELECTROLYTIC CAPACITORS

Highest quality and longest operation life have been achieved and proven through actual performance tests of up to 64,000 hours (approx. 8 years).

99.99% pure aluminum for the anode and a positively noncorrosive electrolyte make it possible for Siemens to project performance capability and failure rates accurately for usage up to 100,000 hours (approx. 12 years). Special sealing technique and choice of materials assure longest possible operational span of electrolyte.

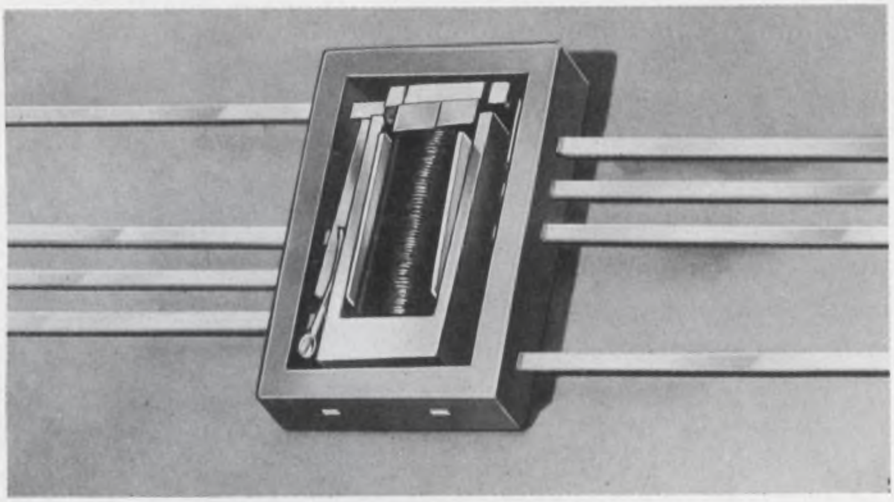
Siemens electrolytic capacitors are capable of operating as long as other more conventionally designed capacitors—such as foil, etc.—due to the special composition of the electrolyte. This composition achieves an optimum of dissipation factor and corrosion. Siemens capacitors operate perfectly at temperatures up to 85° C.

Siemens electrolytic capacitors feature minimum size, maximum performance, and overall adaptability for new applications. Available out of stock in White Plains, N.Y. Send for literature.

SIEMENS AMERICA INCORPORATED
Components Division
230 Ferris Avenue,
White Plains, N.Y. 10603

In Canada: SIEMENS CANADA LIMITED
407 McGill Street, Montreal 1, P.Q.

ON READER-SERVICE CARD CIRCLE 67



TO-87 flat pack houses 1/4-A, 28-V magnetic relay

Still another discrete component, the relay, has been brought to the circuit board via the flat pack. Top dimensions, lead center line distance, lead indexing and numbering of this magnetic relay conform to the JEDEC TO-87 IC package. Designed for low-profile PC board applications, the package measures 3/8 x 1/4 x 1/10-in. with eight peripheral ribbon leads 1/2-in. long and 0.006 x 0.02-in. wide. The leads provide symmetrical connections to the coil and the 1/4-A resistive, 28-V dpdt contacts.

The relay assembly itself has 11 moving parts, including all contacts and case. The armature surrounding the coil is center pivoted to provide static and dynamic balance. The ends of the one-piece core serve as magnetic poles which mate with the armature. The entire magnetic circuit consists of two parts fabricated from heat-treated silicon steel and requires 250 mW of coil power at nominal voltage.

As voltage is applied to the coil, which is wrapped directly on the core over an insulating film, glass-tipped actuators on the armature move the gold-plated silver-magnesium-nickel contacts within each pole with a typical operate and release time of 1 ms. Standard coil resistance for 6, 12 and 24 V is available with special coils to order.

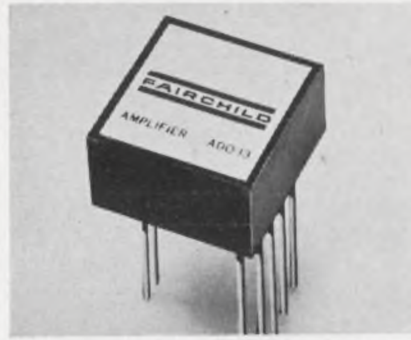
The flat pack is an alumina case entirely insulated from ground (alumina dissipates any moderate coil temperature rise). The eight gold-plated Kovar leads are hermetically sealed through the walls of the package by 1200°C hard glass. The 1/2-in. lead length keeps contact and lead resistance under 0.1 Ω. The cover is hermetically sealed by fluxless gold germanium brazing in an inert gas atmosphere.

Packaging has not compromised relay reliability. The inherent balance of the armature makes it immune to vibrations up to 300 Hz at 50-G levels. The calculated resonant frequency of the moving contact is just under 5 kHz and the relay is rated for 150-G shocks. With factory specified contact pressure, a worst-case plane shock of 265 G would be required to cause a momentary opening of closed contacts. Non-gassing and radiation-resistant materials are used throughout the flat pack relay, rated for Class B temperature, −65 to 125°C.

The extremely small size, light weight (1 gram) and volume (0.01-in.^{3}) of the relay suggest uses in "manportable" communications and weapons delivery equipment. The low profile makes it a natural for high-density printed circuit board packaging of aircraft and missile control systems.

P&A: $45; 60 days (sample quantities). Branson Corp., P. O. Box 845, Denville, N. J. Phone: (201) 625-0600.

Circle No. 221

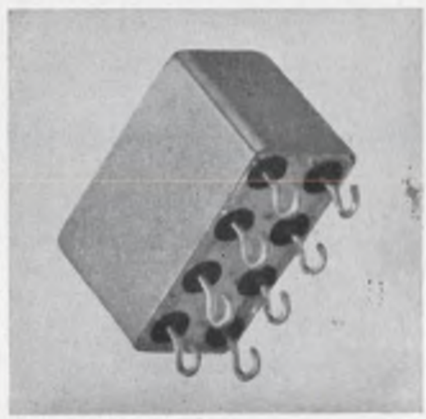


Low-cost 2-mA diff amp

The low-cost ADO-13 differential amplifier delivers 2 mA load current at ±10 V and exhibits good gain stability with changes in load and temperature. Dc open loop gain is 40,000 and gain-bandwidth product is 2 MHz. Voltage drift is 20 μV/°C over a −25 to +85°C range.

P&A: $17 (100 lots); stock. Fairchild Camera & Instrument Corp., Instrumentation Div., Mountain View, Calif. Phone: (415) 962-2011.

Circle No. 222



IC clock oscillator

Model 716 IC clock oscillator is a 0.16-in.^{3} package with digital output for computer, missile guidance and other digital applications. The 716 features a low-aging, high-reliability crystal combined with integrated circuity for 450-ppm stability over −55 to 90°C at frequencies from 701 to 1000 kHz. Output voltage at load is logic zero (0.2 ±0.2 Vdc) and logic one is ±2.8 Vdc minimum. Waveform is square with 20 ns rise time. Current drain is 15 mA. The encapsulated unit is available with pin or cane hook header.

Monitor Products Co., Inc., 815 Fremont, S. Pasadena, Calif. Phone: (213) 682-3761.

Circle No. 223

HELIPOT CUTS THE SIZE OF ITS 10-TURN POT

but there's not a spec of difference

It's true . . . Helipot *actually* cut the length of its ⅞″ diameter 10-turn in half. No hocus pocus. The new Model 7266 is ¾″ long . . . the shortest 10-turn ⅞″ diameter precision potentiometer you can buy. Yet its precision performance is unscathed, and the wirewound resistance element is actually *longer* than that of its predecessor. It is a *precision* pot in every respect. Resolution is better, the total resistance range is still 10 ohms to 125K, with ±0.2% linearity as good as ever.

How much was the price raised? Not a penny —it's priced at $10 for 1—9 pieces and well below $8 in quantity. (And you get two for the size of one.) Complete product information is available now from your local Helipot sales office.

Beckman® INSTRUMENTS, INC.

HELIPOT DIVISION

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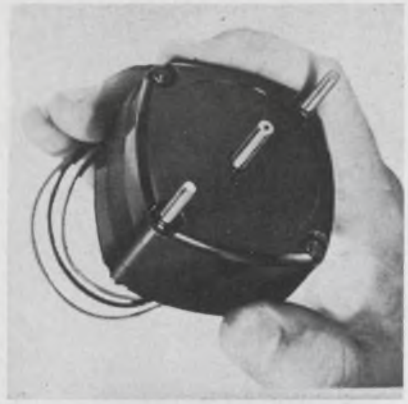
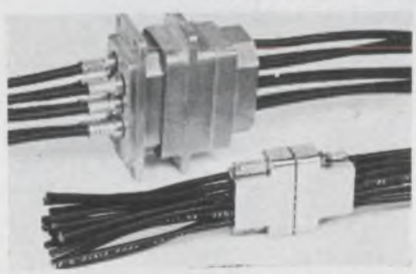


Epoxy-insulated motors

This line of synchronous and induction motors has an epoxy-insulated staton. The motors have speeds from 1 to 1800 rpm at torques from 0.3 to 150 oz-in. Two permanently lubricated ball bearings support the aluminum die-cast rotor. End thrust and rotor are individually adjusted. The 4-pole single-phase motors operate on 115 volts, 50 or 60 Hz. The reversible motors will satisfactorily operate under continuous or intermittent duty applications.

Amphenol, 120 S. Main St., Janesville, Wis. Phone: (608) 754-2211. *Circle No. 224*



Plated plastic connector

Ground loops, oscillations and feedback RFI are reduced by this plated plastic connector. The metal-plated plastic connector maintains shielding throughout and has removable coax contacts. The connector is molded glass-filled phenolic and plated tin over nickel.

When the contacts are inserted into the connector body, the shield termination contacts the metallic coating of the body via springs in contact with both the connector body and contacts. Thus, all cable shields are commoned through the metallic coating of the connector body.

Burndy Corp., Norwalk, Conn. Phone: (203) 838-4444. *Circle No. 225*

33-channel comb filter covers 22 to 45,000 Hz

The frequency range of 22 Hz to 45 kHz may be divided into 33 equal-resolution frequency bands by this octave comb filter. The frequency divider consists of 33 fixed 1/3-octave band filters followed by 33 emitter followers for channel isolation. Each filter may be loaded with a minimum of 15 kΩ in parallel with a maximum capacity of 300 pF. Coax connecting cables up to 10 ft in length may be used. The instrument may be easily adapted to many applications including parallel or real-time frequency analysis, transient analysis, and correlation or cross-spectrum analysis. It can also be used as a sequentially read-out 1/3-octave band analyzer or as the frequency divider of high-speed data analysis systems.

The all solid-state device may be rack-mounted and operated without access to the front panel.

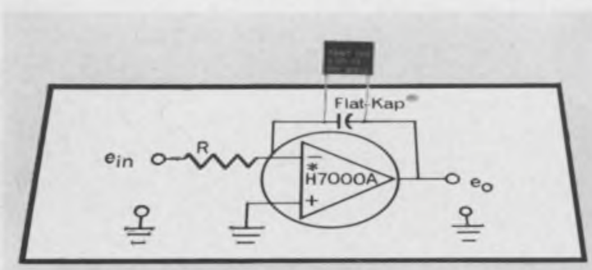
P&A: $3270; stock. B&K Instruments Inc., 5111 W. 164th St., Cleveland. Phone: (216) 267-4800. *Circle No. 226*

Transistor active filters

LC band pass responses are simulated by these transistor active filters at audio and sub-audio frequencies. A single-resonant or a double-tuned coupled-circuit band pass response is obtained by using a twin-T null network in negative feed-back around a linear high-gain transistor op-amp. The silicon transistor amplifiers with emitter-follower output have a low-noise silicon input transistor or high-impedance field effect input transistor.

White Instrument Laboratories, Box 9006, Austin, Tex. Phone: (512) 453-6621. *Circle No. 227*

How to make a better integrator smaller.



Put a KEMET Flat-Kap capacitor in the circuit. Minimize integrating errors by combining Flat-Kap's high IR with extremely low input current (100 picoamperes in our H7000A Operational Amplifier, for instance). And you add real miniaturization to this high accuracy because Flat-Kaps are smaller than ordinary polystyrene, glass or mica capacitors.

The reason is Flat-Kap's remarkable new dielectric, a Union Carbide development called Parylene. It is vacuum-vapor-deposited in micron-range thickness on the aluminum foil conductor. Yet, even in such a thin layer, it holds Flat-Kap's IR at rated voltage and 25°C to 10^6 megohms, minimum.

Typical retrace stability for Flat-Kaps is 0.1% from cycling, use or storage, over the full operating range from −55° to +125°C, with nominal TC −200 ppm/°C. They are available in any value from 0.001 to 0.100μF, 50 VDC, with tolerances as tight as ± 1%.

Where you want maximum volumetric efficiency in a stable capacitor for such applications as integrators, filters and timing circuits—think of KEMET Flat-Kaps. For details, mail the coupon, or see your nearby sales representative.

Clip, fill in name and title, attach to letterhead.

Union Carbide Corporation
Electronics Division, Dept. ED-104
270 Park Avenue, New York 10017

Please send Engineering Bulletin #22, on KEMET Flat-Kap film-foil capacitors

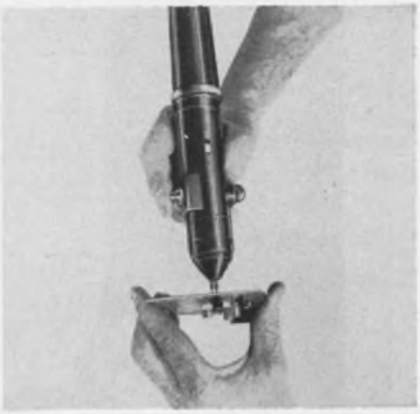
Name________________

Title________________

UNION CARBIDE
ELECTRONICS

REGIONAL SALES OFFICES. New England: T. J. Roper, 300 First Ave., Needham Heights, Mass. Phone: 617-444-5400. **Mid-Atlantic:** R. H. Robecki, 1341 Hamburg Turnpike, Wayne, New Jersey 07472. Phone: 201-696-2710. **Mid-West and South:** K. S. Collart, P. O. Box 6087, Cleveland, Ohio 44101. Phone: 216-221-0600. **West Coast:** D. Purcell, 701 East Whittier Boulevard, Whittier, California 90605. Phone: 213-698-8077.

ON READER-SERVICE CARD CIRCLE 71



Transistor tester

A hand-held tester checks transistors and diodes without unsoldering while they are still in the circuit. The SC-4 consists of three parts: a battery holder at the rear, a central housing incorporating electronics, indicator light, and selector switches, and a forward pick-up section consisting of three spring-loaded pins with TO-5 spacing. The entire unit weighs 6 oz and measures 9-in. long by 1-1/4-in. diameter.

The operator sets the selector switch to npn or pnp and presses the contact pins against the transistor's PC connections. Cut-off conditions are determined by noting the pilot light on the tester. The push-button is then depressed and conduction conditions are determined by again observing the pilot light. Burned out and shorted devices are readily identified. An adapter to test diodes and a set of extending leads and clips are furnished to test unmounted components.

P&A: under $90; stock. Jensen Tools & Alloys, 3630 E. Indian School Rd., Phoenix, Ariz. Phone: (602) 955-0180. *Circle No. 228*

Continuity tester

At a rate of two a second, this device can test up to 944 circuits or wires in a cable form. With a bridge or universal measuring instrument, the continuity tester can check levels of inductance, capacitance and resistance. The front panel contains banks of 91-hole sockets arranged in pairs. Corresponding plugs are connected to the wires at the end of the cable form.

Price: $1932. Technivision Engineers Ltd., Braywick House, Maidenhead, Berks., England.

Circle No. 229

Aerosol freezing agent cools hot components

Sprayed on a suspected resistor, capacitor or other circuit element, "Component Freeze" reduces the surface temperature of the component to −50°F in seconds for a go-no-go test. This saves time lost in waiting for a circuit to cool before testing for the intermittent component. Another application is in the prevention of heat transfer during soldering or welding. A removable extension nozzle confines the spray to a very small area, which is advantageous for both testing and soldering operations. The product is nontoxic and nonflammable.

Miller-Stephenson Chemical Co., Inc., Rte. 7, Danbury, Conn. Phone: (203) 743-4447.

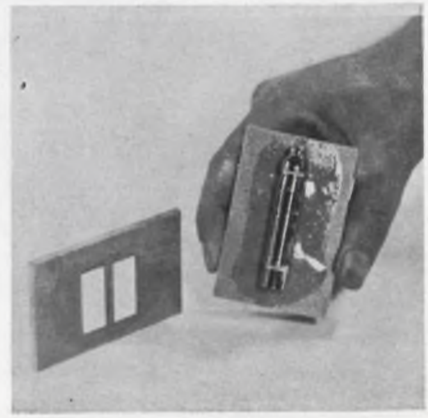
Circle No. 230

Miniature pins

Provided with rounded ends for plug-in relays and semiconductor devices, miniature pins are available in copper, nickel, nickel-clad copper, copper-clad iron, nickel-iron-cobalt alloys and Dumet. Pin lengths run up to 1/2 in. and diameters range from 0.015 to 0.05 in. Pin diameter tolerance is ±0.00025 in. and length tolerance is ±0.003 in.

Price: $0.25 to $0.50/M. General Electric Co., 21800 Tungsten Rd., Cleveland. Phone: (216) 241-0405.

Circle No. 231



Temporary adhesive for substrates and crystals

"Crystalbond 509" is an acetone-soluble adhesive designed as a temporary bond for holding crystals, glass components and ceramic substrates for machining, slicing, grinding and polishing. The thermoplastic polymer material will bond readily to metals, glass or ceramic surfaces, and will not clog cutting blades or grinding media. After machining, the adhesive can be removed with an acetone rinse. Application is made by pressing a 7/8-in. diameter, 7-in. long stick of the material against a preheated plate at 160 to 170°F so that a melted layer is deposited. After spreading, the substrate or crystal is worked into the adhesive, and as the temperature drops below 150°F, the bond solidifies.

P&A: $25 (5 sticks); stock. Aremco Products Inc., P. O. Box 145, Briarcliff Manor, N. Y. Phone: (914) 762-0685.

Circle No. 232

Metal crystals

Produced by electron beam processes, single crystals of very high purity metals such as aluminum, copper, gold and other low melting point metals and their alloys are available. Sizes are up to 1 in. diameter and 6 in. length. Surfaces can be provided to within 1° of specified orientation.

P&A: about $40/in. (1/2-in. diameter); stock to 1 wk. Materials Research Corp., Orangebury, N. Y. Phone: (914) 359-4200.

Circle No. 233

The top name in portable power

Sonotone rechargeable nickel-cadmium sealed cells, of course.

Whenever the need for portable, rechargeable power is indicated, you'll find Sonotone nickel-cadmium sealed cells playing a powerful supporting role.

Pioneer in the development of low weight, constant voltage, sintered-plate nickel-cadmium batteries, Sonotone today is a leader in the production of rechargeable portable power cells.

Produced in more than 27 shapes and sizes, Sonotone sealed cells provide the dependable, continuous voltage output needed to turn motors, light lights, activate switches, power electronics . . . in everything from Titans to cordless carving knives.

If you need any better indication of Sonotone's capabilities in the rechargeable sealed cell field, just tell us your problem. We'll help you with whatever technical data or engineering aid you require. And probably just the cell you need, whether you're looking for 1 or 1 million. If not—we'll make it.

No idle claim. Sonotone has more technical experience in designing, developing and producing nickel-cadmium cells and batteries than any other manufacturer around!

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Aircraft, Missile and Satellite Batteries • Power Supplies • Battery Charger/Analyzer

Looking for a more challenging opportunity? Join Sonotone's fast-growing engineering team in the sky-rocketing field of nickel-cadmium battery design and development. *An equal opportunity employer.*

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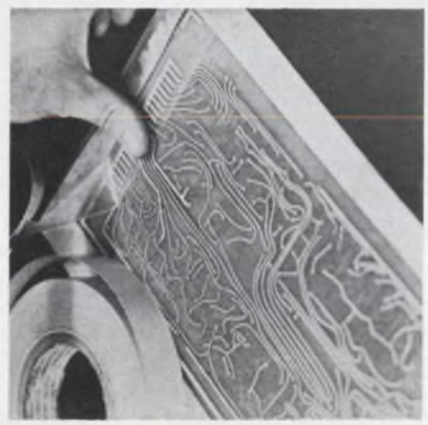
Fiber optic light guides

Transmitted light intensity is not lost when this plastic fiber optic light guide is bent into arcs having a 1/4-in. radius. The protectively-jacketed material withstands repeated vibration and is amenable to maching processing. The light guides are available in a kit which includes two 2-ft lengths of light guide, one with 16 fibers and one with 64, concentrating lens, penlight source, an adapter for connecting guides and polishing and capping materials.

P&A: $10; stock. Edmund Scientific Co., 105 E. Gloucester Pike, Barrington, N. J. Phone: (609) 547-3488.

Circle No. 234



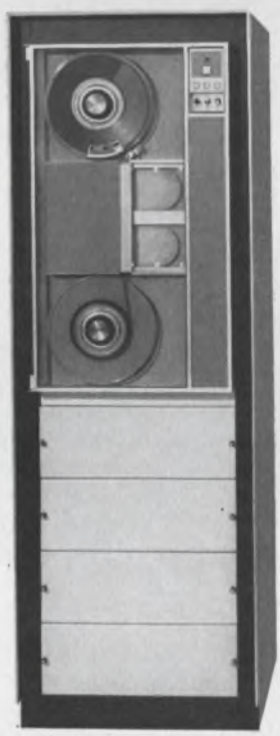
Stop-off film for PC board etching

Pressure-sensitive film in roll form is used for stop-off or masking purposes during etching or secondary operations in processing printed circuits. The film is unaffected by most sulphates including sulphuric acid, ammonia persulphide and metex, ferric chloride, and rhodium, gold, copper and nickel salts. Thickness of the film is 0.002-in., roll length is 200-ft and widths available are 1/2, 3/4, 1, 2, 3 and 4-in.

Morgan Adhesives Co., 4560 Darrow Rd., Stow, Ohio. Phone: (216) 688-8255.

Circle No. 235

This New 3M Asynchronous Digital Recorder writes data at the rate of 2000 characters per second



See it at Booth 1139, Fall Joint Computer Conference, Nov. 8-10, San Francisco

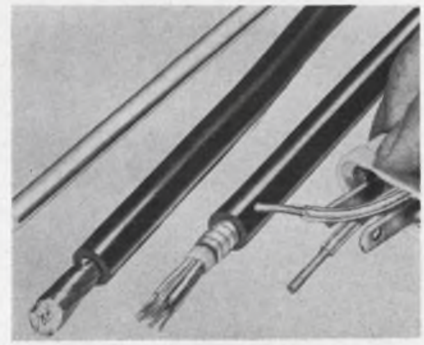
Revere-Mincom's new ADR-100 records during the start interval —that's why you never lose any data in the asynchronous mode, and why this 3M system accepts data at least four times faster than any other asynchronous digital recorder available to date. 2000 characters per second, internally produced inter-record gap if required.

Perfect backup for all IBM systems. Using IBM-compatible 7- or 9-channel tape format, ADR-100's packing density (up to 800 bpi) is due to improved skew control with skew rated at less than 250 microinches. Single-capstan friction drive, no pinch rollers.

Developed and manufactured by the leader in instrumentation recording — Revere-Mincom in Camarillo.

Revere-Mincom Division 3M COMPANY
300 SOUTH LEWIS ROAD • CAMARILLO, CALIFORNIA 93010

ON READER-SERVICE CARD CIRCLE 77

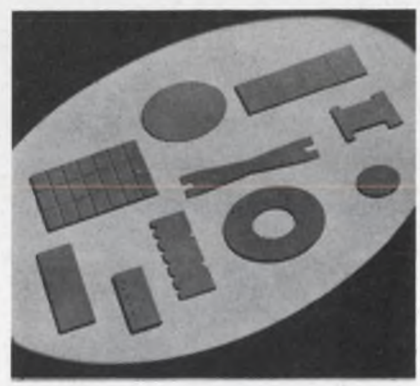


Copper-clad Al wire

This metallurgically bonded copper/aluminum composite is for use in copper-conserving applications including communications cable, coax cable, bus bar, magnet wire and harnesses. Copper-clad aluminum wire is lighter and less expensive than solid copper. Wire sizes are available from 0.3 to 0.005 in. in diameter and in coil weights up to 5000 lbs.

Texas Instruments Inc., Attleboro, Mass. Phone: (617) 222-2800.

Circle No. 236



Thick film substrates

High-alumina ceramic substrates are designed for the integrated thick film circuitry used in telecommunications, computers and control units. The nonporous substrates are made from a sintered alumina ceramic which rivals diamonds in hardness. The material is highly resistant to mechanical and thermal shock, and will withstand most chemicals and corrosive atmospheres. The substrates can be shaped to a number of configurations, including holes or notches for anchoring terminals and depressions or cut-outs for locating discrete components.

Royal Worcester Industrial Ceramics Inc., 11 E. 26th St., New York. Phone: (212) 683-7139.

Circle No. 237

Coax cable

RF shielded by a solid jacket, this cable has a 0.013-in. OD and can bend on a 1/16-in. radius. Available in lengths up to 10 ft, the cable has an impedance of 50 Ω and capacitance of 29.3 pF/ft. The outer conductor is a close-tolerance seamless tube of OFHC copper and the center conductor is silver-plated copper-clad steel wire of 0.0025-in. diameter.

Uniform Tubes, Inc., Collegeville, Pa. Phone: (215) 489-7293.

Circle No. 238

Polyester film

Transparent mylar polyester film is made from polyethylene terephthalate. It functions as an electrical barrier in capacitors and motors. This film has a dielectric strength of 7500 V/mil for one mil film and tensile strength of 25,000 psi. Dielectric constant at 25°C and 60 Hz is 3.30 and dissipation factor is 0.0025. Volume resistivity is 10^{18} Ω-cm.

E. I. DuPont DeNemours & Co., Wilmington, Del. Phone: (302) 774-1000.

Circle No. 239

Acid-gold plating

Producing gold electroplate of 99.99% purity, this acid-gold plating process yields a pore-free highly ductile deposit meeting MIL-G-45204. A deposit of 0.0001-in. over nickel will withstand temperatures of up to 700°C for 5 minutes without discoloration. This process is well adapted to plating PCs, transistors, contacts, diodes, connectors, switches and relays.

Engelhard Industries Inc., 113 Astor St., Newark, N. J. Phone: (201) 242-2700.

Circle No. 240

21-range dc meter

Quantitative readings from 0.2 μA full scale to 1 A are made by this dc meter. The unit has a bifilar suspension system with a weightless light beam pointer which projects a sharp hairline for direct readout. Reading resolution is better than 0.1% and resistance is about 20 kΩ at 0.2 μA. Energy consumption is 8 x 10^{-10} W. The meter can be provided with an accuracy of 0.25% or 0.5% full scale.

Greibach Instruments Corp., 315 North Ave., New Rochelle, N. Y. Phone: (914) 633-7900.

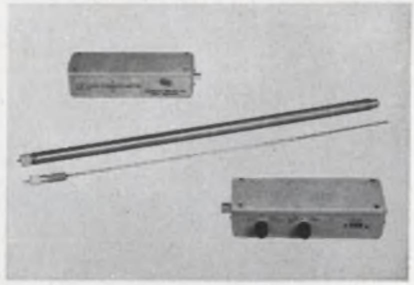
Circle No. 241

Radiometer

Without any balancing this radiometer measures capacitance directly from 0.02 to 1000 pF or makes comparison measurements where the difference between a standard capacitor and an unknown capacitor is measured from 0.02 to 1000 pF. The 1-MHz crystal-controlled test signal meets MIL specs. Stray capacitance from a capacitor to its surroundings does not affect the measurement. A guard circuit is included.

The London Co., 811 Sharon Dr., Westlake, Ohio. Phone:(216) 871-7980.

Circle No. 242



Vlf field strength meter

Operating from an internal rechargeable Ni/Cd battery, this meter measures field intensity at two crystal-controlled frequencies within the vlf band. The whip antenna may be calibrated directly to a standard field. With solid-state silicon design this unit has a 100-dB dynamic range from 1.5 μV/m to 150 mV/m. The 1-kHz sine wave output may be used for recording field intensity or for audio monitoring with headphones.

Aerospace Research, Inc., 130 Lincoln St., Boston. Phone: (617) 254-7200.

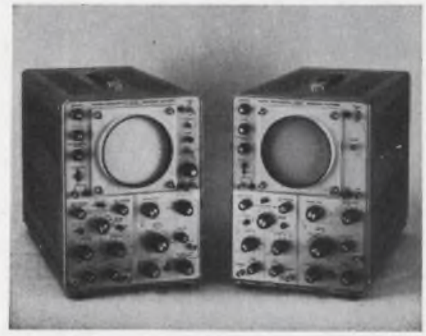
Circle No. 243

S-band signal generator

For calibration of FM receivers, these generators cover the 1435- to 1535-MHz and 2200- to 2300-MHz bands. The coded FM output may be applied directly to receiver/decoders to determine sensitivity or decoder response. With a simple antenna, the units may be used as a calibrated low-power transmitter. They provide an internal 10-channel coder for frequency-modulating the RF signal. RF output is calibrated in carrier frequency, amplitude and deviation.

Pacific Industries Inc., RS Electronics Div., 795 Kifer Rd., Sunnyvale, Calif. Phone: (408) 739-3230.

Circle No. 244



5-MHz scopes

Both model 802 storage scope and model 831 standard scope offer single-switch selection of seven operating modes and single channel operation of either A or B channels at 5 MHz and 20-mV/division sensitivity. Also offered are dual channel operation chopped or alternate, A and B added algebraically and X-Y operation fully calibrated in both axes. Common mode rejection is 1000:1 and selectable bandpass is 600 or 10 kHz. These scopes have stable triggering beyond the bandpass of the scope.

P&A: $995 (model 831); stock. Hughes Aircraft Co., 2020 Oceanside Blvd., Oceanside, Calif. Phone: (714) 722-2101.

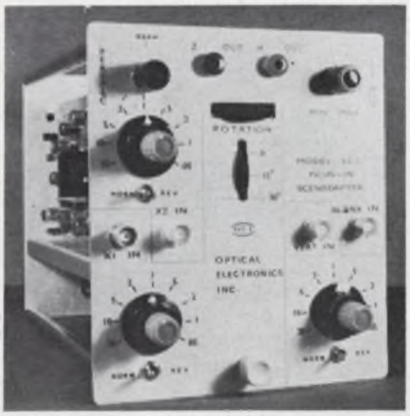
Circle No. 245

Power signal generator

Covering the frequency range of 2.3 to 7.0 GHz in one band, this signal generator features up to 3-W output. Type SLRC is a disc-seal triode oscillator which is capable of being synchronized. Using a built-in directional coupler, output power is indicated on a panel meter. For lower power levels, a 100-dB relative calibrated piston attenuator is used. Frequency indication is on a digital read-out.

P&A: $6600; stock. Rohde & Schwarz Sales Co., 111 Lexington Ave., Passaic, N. J. Phone: (201) 773-8010.

Circle No. 246



Plug-in converts scopes to 3-D

With the model 627 plug-in "Scen-adapter," the user can quickly convert series 530, 540 or 580 Tektronix scopes into three-dimensional display instruments. The all-solid-state plug-in features controllable linear perspective, aerial perspective (intensity shading) and operator-controlled scene rotation in two degrees of freedom. Frequency response is 1 Hz to 100 kHz, input impedance is 1 MΩ on each of the three independent orthogonal deflection inputs and maximum sensitivity is 0.05 V/division.

P&A: $1095; 30 days. Optical Electronics Inc., P. O. Box 11140, Tucson, Ariz. Phone: (602) 624-3605. *Circle No. 248*

Transistor tester

With automatic handlers, this go/no-go test instrument tests over 4000 transistors per hour. It performs standard industrial dc tests in 35 ms each. The tester has built-in oscillation suppression and detection circuits and a pin-board matrix which translates test results into single bin decisions. The device tests power transistors and diodes up to 600 V and 1 A. Cutoff and leakage tests can be made down to 100 pA.

P&A: $16,500; 90 days. Teradyne, Inc., 183 Essex St., Boston. Phone: (617) 426-6560.

Circle No. 247

Ballantine Announces a New Solid State DC Digital Voltmeter

Gives you fast, accurate readings to 0.02% ± 0.01% f.s. and at a low cost of just $490

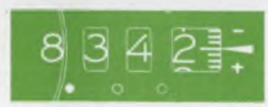
Ballantine's new Model 353 enables you to speed up dc measurements materially over those made on multi-knob differential voltmeters. And with laboratory accuracy from 0 to 1000 volts dc.

It requires just two steps: (1) Set knob to NORMAL mode and read voltage; (2) dial in the first digit in EXPAND mode and read voltage to four places with over-range to five; and, in addition, interpolate to another digit.

The NORMAL mode error becomes submerged by more than ten to one, and the operation is fast and accurate to 0.02% of reading ±0.01% f.s. If the input signal is varying, the last digit may be followed visually, thus providing the advantage of analog display.

Step 1. NORMAL Mode 8.342 V

Step 2. EXPAND Mode 8.3420 V



Example of "Overrange" presentation 108.340 V

Note these other interesting features of the new 353: a left-to-right digital readout; an automatic display of "mV" or "V"; proper placement of the decimal point; 10 megohms input resistance; an automatic disabling of the motor during the "expand" dialing; a red light to indicate overrange or wrong polarity; and provision for a foot-operated switch for a "read" or "hold" function.

Write for brochure giving many more details

— Since 1932 —

BALLANTINE LABORATORIES INC.

Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR DC AND AC ELECTRONIC VOLTMETERS/AMMETERS/OHMMETERS, REGARDLESS OF YOUR REQUIREMENTS. WE HAVE A LARGE LINE, WITH ADDITIONS EACH YEAR. ALSO AC/DC LINEAR CONVERTERS, AC/DC CALIBRATORS, WIDE BAND AMPLIFIERS, DIRECT-READING CAPACITANCE METERS, AND A LINE OF LABORATORY VOLTAGE STANDARDS FOR 0 TO 1,000 MHz.

Speed Inquiry to Advertiser via Collect Night Letter

ON READER-SERVICE CARD CIRCLE 81

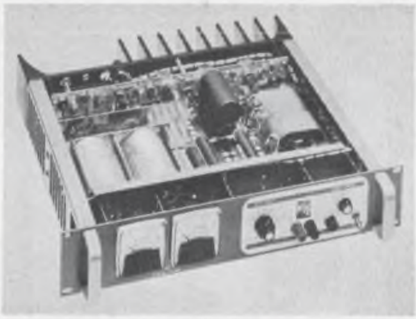
TEST EQUIPMENT

Angle indicator

This angle indicator receives synchro and/or resolver information from a remote location and provides a digital readout with a resolution of one minute of arc. The design of the gear train allows the addition of up to six size 11 components to provide re-transmission of the input data in other forms or at different impedance levels. A self-contained source will drive the unit to 0° at any time. Standard accuracy is ±6 minutes with a repeatability of 30 s and slew speed is 25°/s.

Linair Design Corp., 1016 E. Elizabeth Ave., Linden, N. J. Phone: (201) 925-4970.

Circle No. 249



Regulated dc supply

Simultaneously offering current or voltage limiting, this regulated dc supply may be used alternatively as a voltage regulated power supply or as a current regulated power supply. The unit has an output of 0 to 36 V and 0 to 5 A with a 4-A input. Regulation for load and line changes is 0.005% or 0.5 mV and 0.01% or 1 mV respectively when operated as a voltage regulated power supply. Current regulation load is 1 mA/V change in output and 1 mA in constant current lines.

Price: $330. NJE Corp., 20 Boright Ave., Kenilworth, N. J. Phone: (201) 376-7300.

Circle No. 250

Send us a cable.

Send us a small sample, at least one foot, of the coaxial cable you're using and tell us what you're using it for. Then we'll install the Burndy crimp removable coax contact that'll do the job best. Guaranteed.

A tough job? Not really.

Remember, crimp removable contacts began at Burndy. As a result Burndy offers the most complete line of coaxial connectors for standard, miniature and sub-miniature coaxial cables. And they're available for all rectangular, rack and panel and terminal block configurations.

Send your sample along to Mr. M. Elkind, Product Manager, Burndy, Norwalk, Conn. He'll see that the job is done and returned quickly. You'll receive our latest coax connector catalog, too.

BURNDY

NORWALK, CONNECTICUT

INTERNATIONAL SALES HEADQUARTERS AND MANUFACTURING FACILITIES:
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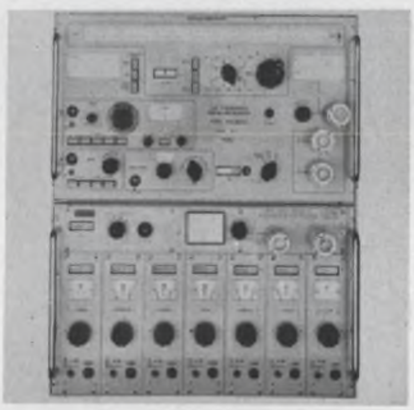
ON READER-SERVICE CARD CIRCLE 83

Digital voltmeters

Featuring ±0.05% reading ±1 digit, these digital voltmeters provide reading time of 0.6 s filtered or 20 ms with filter bypassed, constant input impedance of 10 MΩ and BCD output. A reading storage feature provides bidirectional tracking without blinking. Model 251 has resolution to 1 part in 10^3 and ranges of 9.999, 99.99 and 999.9 V. Model 252 has resolution to 1 part in 3000 and ranges of 2, 20, 200 and 1000 V.

P&A: $525 (model 251), $435 (model 252). United Systems Corp., 918 Woodley Rd., Dayton, Ohio. Phone: (513) 254-3567.

Circle No. 251

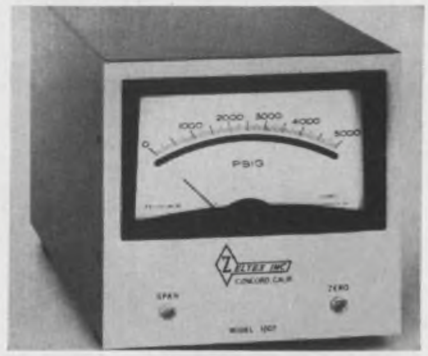


Signal generator

For AM/FM measurements requiring a carrier in the 300-Hz to 470-MHz range, this synthesizer generator has a crystal accuracy of 0.003 ppm. Output level is 1 V stabilized with 50-Ω impedance. Spurious rejection is better than 80 dB for nonharmonics. Deviation range is 0 to 100 kHz internal and external (phase locked). Sweep provision is ±100 kHz electronically and 1 to 10 MHz mechanically. Attenuator is 0 to 99 dB, 40 to 139 dB in 1-dB steps.

P&A: $8200; 90 to 120 days. E. F. Associates Inc., 207 Park Ave., Scotch Plains, N. J. Phone: (201) 322-6471.

Circle No. 252

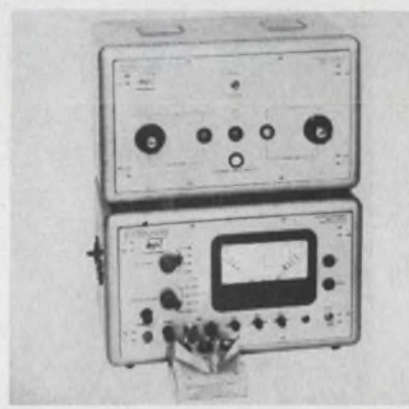


Signal monitor

Parameter sensors in real time are monitored by this differential dc millivoltmeter. Model 1007 has an adjustable zero point up to ±100% of full scale and dc input range selectable from 5 to 50 mV full scale. Input impedance is 100 kΩ, linearity is 2% of full scale and input isolation is 100 MΩ from ground. Ac pumpout is 1 mV rms, dc pumpout is 10 μV max and drift is 0.1% max. Output drift is 1% max over an 8-hour period.

Zeltex Inc., 1000 Chalomar Rd., Concord, Calif. Phone: (415) 686-6660.

Circle No. 253



Component comparator

Model CZ 457 compares resistors, capacitors and inductors with a standard and indicates the percentage deviation. Measuring ranges are 0.01 Ω to 15 MΩ, 0.02 pF to 10 μF and 2 pH to 100 H. Over-all accuracy is 0.1%. With an automator (CZII 457) the system becomes a high speed test set with relay outputs for sorters. Tolerances can be assymetrically set by pots between 0.2% and 22%.

P&A: $450 (comparator), $490 (automator); 2 wks. Amark Corp., 31 Commercial St., Plainview, N. Y. Phone: (516) 938-3322.

Circle No. 254

Impulse printer

Operating at 1000 counts per minute, this impulse printer automatically totals and prints units counted or elapsed job time on a strip-chart at preset time intervals or at a selected time. It monitors and prints a record of units counted and time of day. The printer can also operate at 10,000 per minute with an optional 10:1 scaler. Chart rolls can operate at speeds of 1, 4, 12 and 60-in./h.

Standard Instrument Corp., 115 Fifth Ave., New York. Phone: (212) 673-3311.

Circle No. 255

Tape recorder

Equipped with 8-1/2-in. reels, this magnetic tape recorder has three selectable speeds from 15 to 150 ips. Compatible with 7- and 9-channel IBM 360 tape formats, the units are mounted on slides for complete access to all components. Start time is 50 ms max, stop time is 100 ms max and temperature range is 32 to 125°F. Shock is 5 G for 11 ms for all axes and vibration is 5 to 35 Hz.

Potter Instrument Co., Inc., 151 Sunnyside Blvd., Plainview, N. Y. Phone: (516) 681-3200.

Circle No. 256

From CEI . . . a New Family of Pre-Tuned, Crystal-Controlled

Pulse and AM Receivers

• 4 AM AND 4 PULSE MODELS • COVER 60 MHz TO 150 MHz • COMPACT, ALL SOLID STATE

TYPE 415 AM RECEIVER

TYPE 416 PULSE RECEIVER

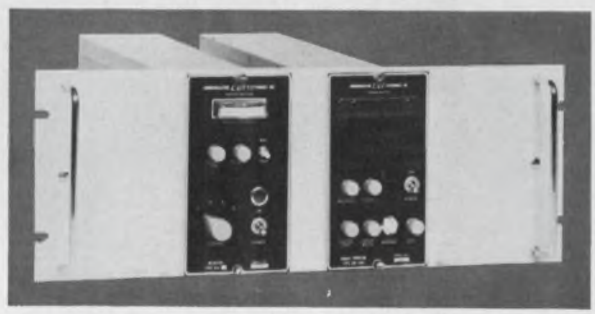
Introducing two new series of top-performing CEI receivers . . . the Type 415 for AM and Type 416 for Pulse reception. Both series cover the 60-150 MHz range using standard tuners.

Each receiver is a completely transistorized, fixed-tuned unit allowing the selection of any of four preset channels within its frequency range (see table at right for ranges of individual receivers). The four channels are factory-set to your requirements and may be easily and swiftly reset, when necessary, by field maintenance personnel.

The AM units are available with a choice of 50 or 100 kHz bandwidth. Compact and lightweight, *all* these receivers offer high sensitivity and reliability and require very little power—just 3½ watts.

Signal monitor outputs of 21.4 MHz have been provided, and a matching signal monitor (CEI Type SM-4301) may be mounted alongside one or more of the receivers to provide a visual display around the tuned frequency.

Special rack-mount equipment frames are also available, designed to accommodate two, three or four of the Type 415, 416, and/or SM-4301 units.



RACK-MOUNTS & SIGNAL MONITOR AVAILABLE— Shown here is a Type 416 Pulse receiver and matching Type SM-4301 signal monitor in an EF-402 equipment frame. Equipment frames are available to mount two, three or four units.

Table of Standard Tuning Ranges
(other frequency combinations on request)

Receiver Type AM	Receiver Type Pulse	Overall Frequency Range (MHz)	Band A Frequency Range (MHz)	Band B Frequency Range (MHz)
415-1	416-1	60-90	60-75	75-90
415-2	416-2	75-110	75-90	90-110
415-3	416-3	90-130	90-105	105-130
415-4	416-4	110-150	110-125	125-150

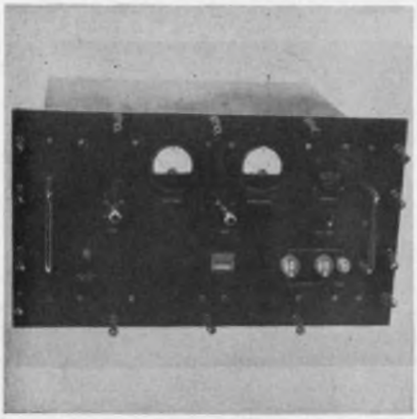
For complete information and specifications, please contact:

CEI

COMMUNICATION ELECTRONICS INCORPORATED

6006 Executive Blvd., Rockville, Md. 20852 · Phone: (301) 933-2800 · TWX: 710-824-9603

ON READER-SERVICE CARD CIRCLE 87

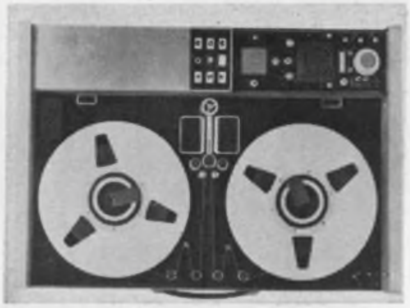


Parametric amplifier

Operating over 2.3 to 2.4 GHz, this parametric amplifier features a noise figure of 2 dB and one-knob frequency tuning. Instantaneous bandwidth is 15 MHz and gain is 18 dB min. Applications include use in communications, radar, radio astronomy and satellite or missile tracking.

Alpha Industries, Inc., 381 Elliot St., Newton Upper Falls, Mass. Phone: (617) 969-6480.

Circle No. 257

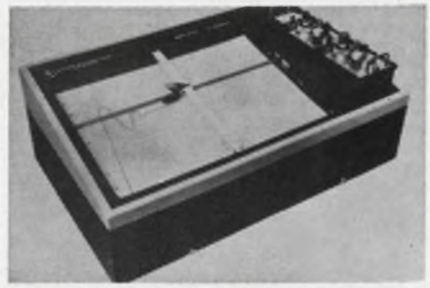


300-kHz recorder

Weighing 90 lbs in a 14-channel record and reproduce configuration, thus unit records signals from dc to 300 kHz. On dc models the low-inertia direct-drive capstan rotates at constant speed, phase-locked to a crystal oscillator to provide less than 0.4% p-p flutter. Flutter on ac models is less than 0.3%. The unit accommodates 1/4-, 1/2-, or 1-in. wide tape on standard 10.5-in. reels. Switch-selectable tape speeds range from 15/16 to 60 ips.

Pemco, 942 Commercial Ave., Palo Alto, Calif. Phone: (415) 321-1177.

Circle No. 258



X-Y recorder

Featuring optional plug-in control modules, this X-Y recorder uses 11- x 16.5-in. paper and has 15-in./s pen speed. The T-O module records dc signals with a sensitivity of 1 mV/in. max. The T-1 module records any variable vs time. The T-2 module, which incorporates functions of the T-0 and T-1, has a wider sweep range speed and parallel-T input filters for ac pickup rejection. The TN module for point plotting data has a null detector. Accuracy of the basic unit is 0.2%.

P&A: from $1500; 2 wks. Houston Instrument Corp., 4951 Terminal Ave., Bellaire, Tex. Phone: (713) 667-9307. *Circle No. 259*

Weston Model 1423 Integrating DVM

1μV Sensitivity at 50 MΩ for $1950.

FEATURES: *Strain gage and thermocouple type measurements are made with meaningful accuracy due to integrating and high sensitivity features of Model 1423. High common mode rejection allows low level measurement of potentials well above ground. Loading errors are reduced by 1000 times as compared to conventional DVM's.*

SPECIFICATIONS: *Accuracy: 0.02% ±1 digit. Common Mode Rejection: 150 db DC & 130 db at 60Hz—with up to 5K unbalance between input leads, and filter in use. Series (Normal) Mode Rejection: 60 db at 60Hz with filter. Overranging: 15% with fifth digit display. Display Time Control: From 4 reading/second to 1 reading/15 seconds. Overall Dimensions: 6½" x 14¼" x 16¼". Price: Bench mount, $1950; rack mount, $1995. Price subject to change without notice.*

Input Impedance & Sensitivity

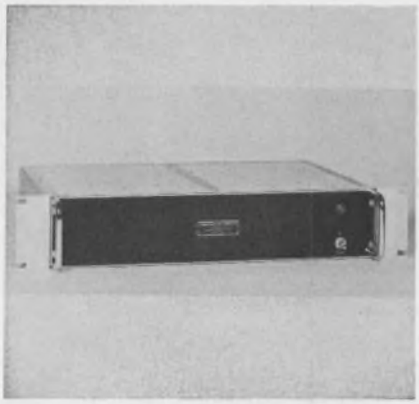
Range	Input Impedance Minimum	Sensitivity
10.000 mV	50 megohms*	1 μV
100.00 mV	500 megohms*	10 μV
1000.0 mV	5000 megohms*	100 μV
10.000/100.00/1000.0 volts	10 megohms	1/10/100 mV

*Typical values twice as large

Contact **Weston Instruments, Inc., Rotek Division, 11 Galen Street, Watertown, Mass. 02172**

WESTON® *prime source for precision . . . since 1888*

ON READER-SERVICE CARD CIRCLE 90



Distribution amplifier

This audio distribution amplifier incorporates five identical etched-circuit amplifiers which deliver 150-Hz to 10-kHz response 2 dB. The unit provides five isolated outputs from a common high impedance input up to 2 V rms. Both 600-Ω (balanced) and 150-Ω outputs are offered. Individual gain levels are adjustable from −6 to 6 dB. Gain stability is within 0.75 dB from 0 to 85°C.

Communication Electronics Inc., 6006 Executive Blvd., Rockville, Md. Phone: (301) 933-2800.

Circle No. 260

Peripheral-drive recorder

This bidirectional magnetic tape recorder employs tape reels with peripheral drive. A polyester belt rides in contact with the tape as it is wound on the flangeless reels. This unit stores up to 2250 ft of 1.1-mil tape to record analog data from dc to 120 kHz or digital data up to 120 kbps. The recorder exhibits 0.9% p-p flutter max. A motor reversing current gives this unit bidirectional operation.

Kinelogic Corp., 29 S. Pasadena Ave., Pasadena, Calif. Phone: (213) 684-0434.

Circle No. 261

L- and S-band preamps

Covering 1435 to 1550 MHz and 2200 to 2300 MHz, these two preamps feature 5- and 6-dB noise figures and do not burn out with 1/2-W max cw input. Power output for both units is 0 dBm at 1 dB and input is −15 Vdc at 25 mA. Minimum gain is 25 dB, input vswr is 1.5 and output vswr is 2.

Availability: 15 to 30 days. Avantek Inc., 3001 Copper Rd., Santa Clara, Calif. Phone: (408) 739-6170.

Circle No. 262

Parabolic antenna

Measuring 4 ft in diameter, this multi-element grid parabola is designed for the 940- to 960-MHz communications band. Gain is 18.9 dBi and beamwidth is 18.9°. Wind loading which is 23% that of a solid dish, gives a thrust of 110 lbs with winds of 100 mph. The antenna has a 7/8-in. EIA termination.

Mark Products, 5439 West Fargo Ave., Skokie, Ill. Phone: (312) 675-1500.

Circle No. 263

Metal-ceramic triode

This metal-ceramic triode can be used as a plate-pulse oscillator or amplifier at up to 6 GHz. Designed for use in a cavity, the 7910 provides 100-W C-band oscillation. The unit has 1200-V peak plate voltage, 1.5-W max plate dissipation and 600-mA video peak plate current. Peak power output at C-band is over 100 W.

General Electric Co., 1 River Rd., Schenectady, N. Y. Phone: (518) 374-2211.

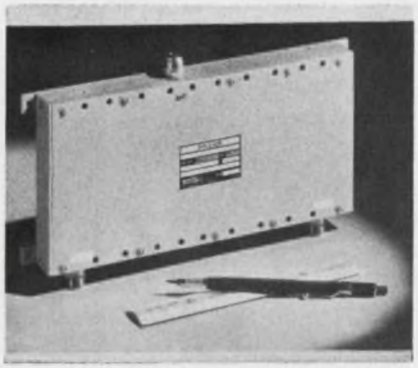
Circle No. 264

Tunnel diode amplifiers

Over a spectrum of 1 to 10 GHz this line of tunnel diode amplifiers has noise figures varying from 4 to 6 dB. Typical noise variation over a 10% bandwidth is 0.5 dB max. Up to 20% bandwidth is available with 3-dB max gain variation and signal gain typically 10 to 20 dB.

P&A: $1500; 60 days. Varian Assoc., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Circle No. 265

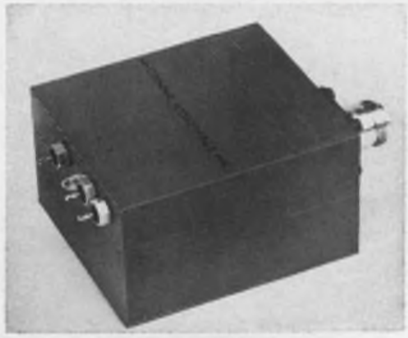


Interdigital diplexer

This interdigital diplexer enables two pieces of equipment of adjacent frequency bands to operate with one broadband antenna. For a band from 650 to 890 MHz, vswr is less than 2.5 and insertion loss is 1.5 dB. For a band from 960 to 1220 MHz, vswr is 2.5. Isolation from the first band to the second band is 65 dB and from the second band to the first is 30 dB. The diplexer meets MIL-E-5400.

Transco Products, Inc., 4241 Glencoe Ave., Venice, Calif. Phone: (213) 391-7291.

Circle No. 266

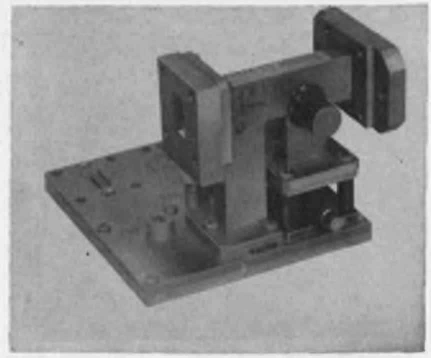


FM-cw tunable source

Capable of accepting FM inputs, this FM-cw tunable source provides an output of 200 mW at 4 GHz. Frequency response is flat within ±1 dB from 5 to 5.5 GHz. Linearity is within 2% for 5-MHz peak deviation. Modulation sensitivity is 30 MHz/V. A diode switch provides 90-dB isolation and can switch up to 7 W cw in 500 ns. This transmitter/-exciter operates from 28 V at 300 mA or −28 V at 250 mA and 5 to 10 V for frequency tuning.

Microwave Assoc., Inc., Northwest Industrial Park, Burlington, Mass. Phone: (617) 272-3000.

Circle No. 267

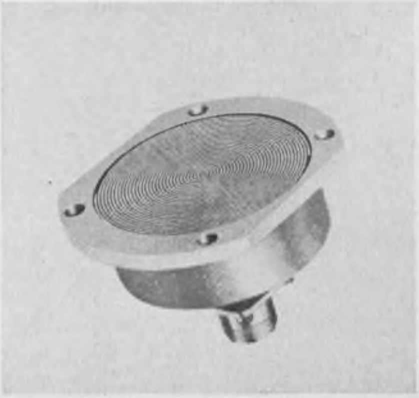


Ku-band mixer-duplexer

Designed for use in airborne radar, this miniature mixer-duplexer has an "air-strip" portion containing a balanced signal mixer and a single-ended automatic frequency control mixer. Local oscillator power is controlled by a 5-dB pad attenuator, a power divider and separate variable attenuators (0 to 10 dB) for each mixer. All microwave inputs are standard Ku-band waveguide.

Micro-Radionics, Inc., 14844 Oxnard St., Van Nuys, Calif. Phone: (213) 873-1100.

Circle No. 268

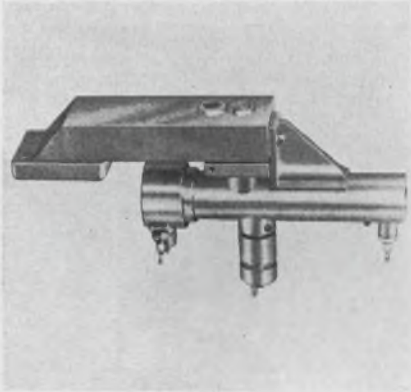


Spiral antenna

Constant impedance and pattern performance are maintained from 2 to 11 GHz by this cavity-backed spiral antenna. Capable of operating at 350°F, the device has envelope dimensions of less than 3 x 2.5 x 2.14 in. A gain level of 7 to 8 dB is maintained over better than a 3:1 band. The circularly polarized antenna has a vswr of 1.5, 3-dB beamwidth of 75°, front to back ratio of 15 dB and axial ratio of 1 dB.

P&A: $325; 6 wks. American Electronic Laboratories, Inc., Box 552, Lansdale, Pa. Phone: (215) 822-2929.

Circle No. 269



X-band oscillator

A range of 9 to 10 GHz with single screw tuning of 300 MHz or electronic tuning of 10 MHz is provided by this X-band oscillator/multiplier. Output is 150 mW min and input requirements are 150 V at 35 mA and 6.3 V at 220 mA. Frequency stability vs temperature is 10 ppm/°C from −54 to 95°C, frequency stability vs plate voltage is 200 kHz/V nominal and frequency stability vs filament voltage is 3 MHz/V nominal.

Trak Microwave Corp., 4726 Kennedy, Tampa, Fla. Phone: (813) 877-8341.

Circle No. 270

Frequency multiplier

With an input of up to 400 mW from 10 MHz to 4 GHz this uhf/vhf frequency multiplier produces high harmonic energy in the 20-MHz to 8-GHz range at efficiencies approaching 200% divided by N, where N is harmonic number. A 100-ps step-recovery diode with a self-contained bias circuit generates the harmonics. Dc blocking is provided at both ports to isolate and protect the bias circuit. A tunable bandpass filter can be used to select the desired output harmonic.

P&A: $130; 10 days. Somerset Radiation Laboratory, Inc., 2060 N. 14 St., Arlington, Va. Phone: (703) 525-4255. *Circle No. 271*

Elliptical waveguide

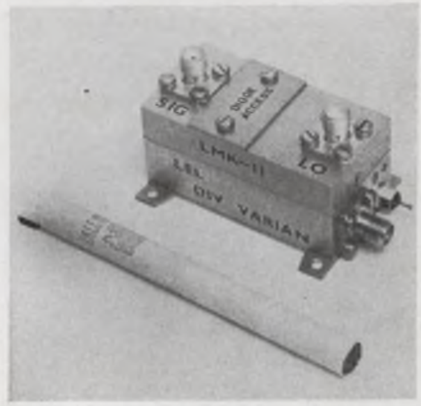
Designed for 1.7- to 2.4-GHz scattered communication systems, this elliptical waveguide has an attenuation of 0.29 dB/100 ft and average power rating of 27 kW. With tuned connectors, a 200-ft length has a vswr of 1.1 max. Available in continuous lengths of up to 500 ft, this flexible waveguide may be formed to a radius of 28 in. in the E plane.

Andrew Corp., Box 807, Chicago. Phone: (312) 349-3300.

TWT amplifier

Providing a noise figure of 6 dB typically, this 2- to 8-GHz double-octave TWT amplifier has a small signal gain of 25 dB min ±3 dB. Vswr input and output is 2.5 max, primary voltage is 115 Vac ±10 Vac and primary frequency is 48 to 420 Hz. Input is 25 W and output is 0 dBm. The amplifier may be mounted in any orientation and can withstand shock, vibration and temperature specs of MIL-E-5400. The unit measures 4.75 x 4.74 x 12 in. and weighs under 18 lbs.

Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. Phone: (415) 326-8830. *Circle No. 272*



Mixer/preamps

Consisting of a microwave mixer integrated with a solid-state IF preamp, these units provide conversion over a range of 0.1 to 12 GHz. IF outputs are available at 30 or 60 MHz in 20-MHz bandwidth. Overall conversion gain is 20 dB and maximum signal input for linear operation is −24 dBm. The 2-oz unit is 2 in.^{3} and requires −20 Vdc at 10 mA.

P&A: $695 to $995: 5 wks. Varian Assoc., LEL Div., Akron St., Copaigue, N. Y. Phone: (516) 264-2200 *Circle No. 273*

Antenna pedestal system

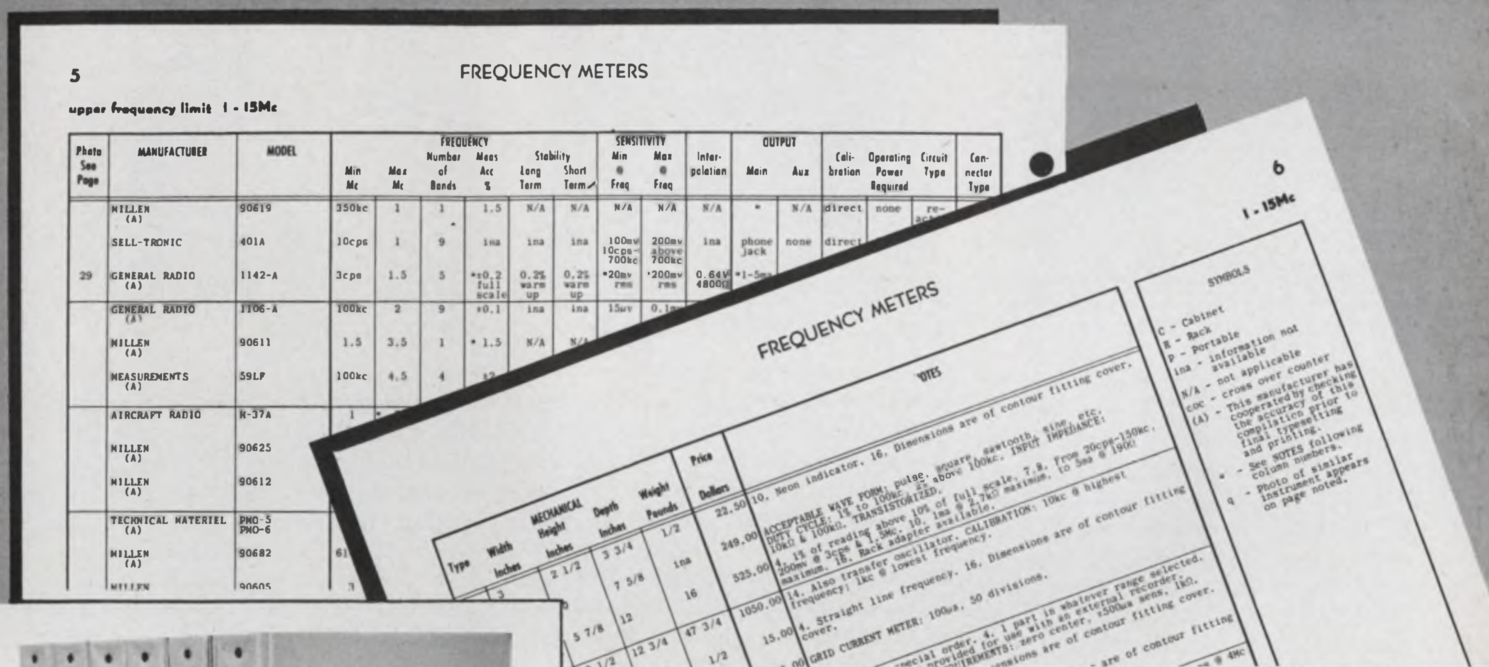
Reflectors up to 40 ft in diameter can be accommodated by this pedestal system. Rms pointing accuracy is 0.002° equivalent to 7.2 arc seconds or 0.035 mils. The orthogonality of the axes is aligned to within 10 arc-seconds, position readout encoders are direct coupled for an error of 3 arc-seconds max due to coupling and the azimuth and elevation bearings are accurate to within 6 arc-seconds.

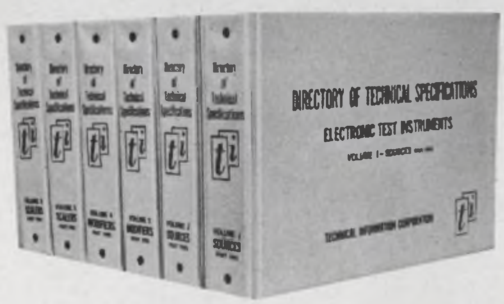
Canoga Electronics Corp., 8966 Comanche Ave., Chatsworth, Calif. Phone: (213) 341-3010.

Circle No. 274

The Standard Reference For Electronic Test Instruments

DIRECTORY OF TECHNICAL SPECIFICATIONS





CONVENIENT TABULAR FORMAT PROVIDES QUICK AND EASY MODEL-TO-MODEL COMPARISONS

One look at the specimen pages will show you—better than words—the extent of the information furnished by the DIRECTORY OF TECHNICAL SPECIFICATIONS and the comparative arrangement of the data. These convenient tables are designed for rapid and accurate point-by-point comparison of instruments having similar functional capabilities. By providing a thorough across-the-market analysis, all alternatives can be considered in selecting the right instrument for any application.

SAVE HOURS OF ENGINEERING TIME

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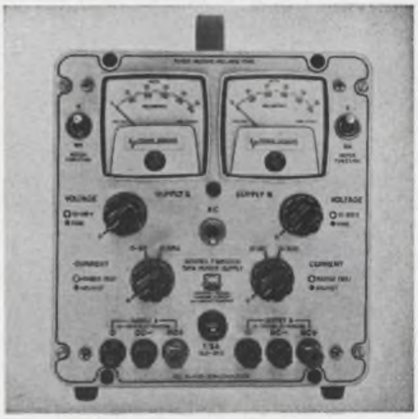
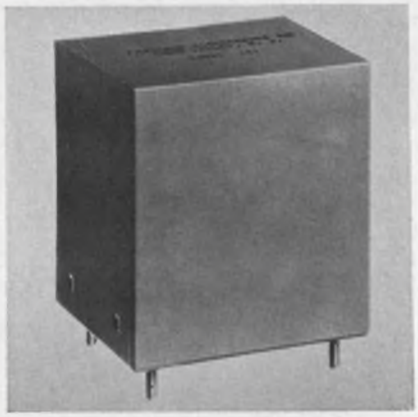


50-V 500-mA supply

Supplying two independent 50-V 500-mA sources, this power supply automatically limits current. Each source has regulation better than 0.005% ±1 mV at both outputs, 1-mV max p-p ripple and temperature coefficient of 0.02%/°C. Impedance is 0.1 Ω max in the constant-voltage mode and more than 200 kΩ in the constant-current mode. Resolution is better than 5 mV and 0.25 mA.

Power Designs Inc. 1700 Shames Dr., Westbury, N. Y. Phone: (516) 333-6200.

Circle No. 275

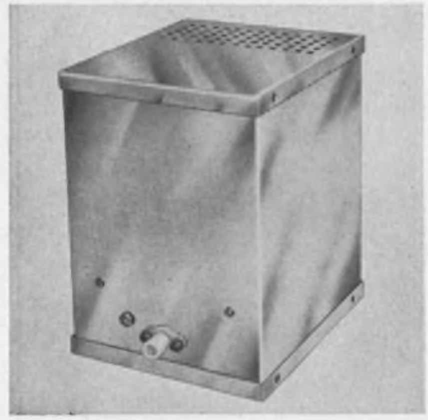


Op-amp power supply

For energizing op-amps or other circuits requiring both positive and negative voltages, this dual supply has a 0.1% regulation when subjected to loads varying from 0 to 50 mA. Two voltages, one at 15 Vdc and the other at −15 Vdc, each delivering 50 mA, track each other to within 0.01%. Stability is better than 0.01% and ripple is less than 0.005%. Input voltage may vary from 105 to 130 Vac at 60 to 400 Hz.

P&A: $75; stock. Fairlane Electronics, Box 335, Long Valley, N. J. Phone: (201) 832-2217.

Circle No. 276

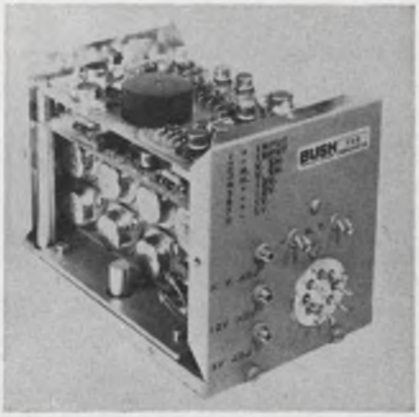


20-kV supply

With an input of 24 Vdc and 1.8 A and an output of 20 kV at 0.5 mA, this dc to dc supply shows a ripple of less than 0.01%. Output may be varied from 1 to 20 kV by controlling the dc input voltage. A 10-kV output at 1 mA requires an input of 15 V at 1.6 A. Frequency is about 20 kHz. The unit is completely shielded and measures 5-3/4 x 8-1/4 x 6-3/4 in.

P&A: $75; 1 wk. Spellman High Voltage Co. Inc., 1930 Adee Ave., Bronx, N. Y. Phone: (212) 547-0306.

Circle No. 277



2-kV supply

Operating from a 24- to 30-Vdc input, this supply puts out 1.7 to 2 kV. Adjustable regulation is 2%. This constant current source with adjustable output charges a 150-mF storage capacitor to 0.3 C in 6 s. Two regulated outputs rated at 5 Vdc adjustable at 3.5 A and 12 Vdc at 0.25 A operate associated circuitry. The unit is suitable for operating laser optic systems.

Bush Transformer Corp., 20 S.W. Park, Westwood, Mass. Phone: (617) 326-8950. *Circle No. 278*

Logic module supply

Capable of supplying 2 A at 12 Vdc, this power supply is convection cooled and uses silicon semiconductors. In an overload condition, output voltage, which cannot exceed 15 V, and current are automatically reduced. Voltage input is 95 to 130 V rms and ripple is 1.25 V rms. Regulation is 1.5% for load and 2.5% for line. Operating temperatures is 0 to 165°F.

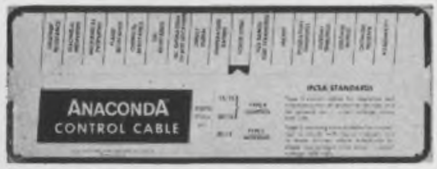
Ault Inc., 3501 48 Ave. N., Minneapolis. Phone: (612) 588-0556. *Circle No. 279*

High-voltage power

Thirty high-voltage power supplies range from 1 kV at 10 mA to 10 kV at 500 mA. All have 0.01% regulation and exhibit 0.002% p-p ripple. They operate from 105 to 125 or 210 to 250 Vac. Metered ±1% for voltage and current, they include adjustable overload protection and, with the exception of the 10 kV types, can be floated off ground up to 7500 Vdc.

P&A: $1550 to $3000; 90 to 120 days. Alto Scientific Co. Inc., 4083 Transport St., Palo Alto, Calif. Phone: (415) 321-3434. *Circle No. 280*

Design Aids



Control cable calculator

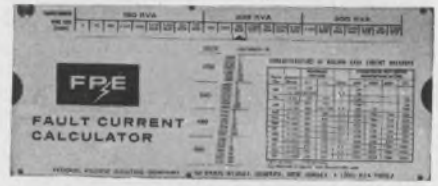
Such characteristics as temperature rating, size range and stranding, insulation thickness and voltage rating can be determined for type B (15/10 and 20/10) control cables and type C (30/15) metering control cable. Type B cables are for operation and interconnection of protective devices and general use. Type C cables are for connection to circuits with heavy magnetic trip or break devices where inductively induced overvoltages may occur. Anaconda Wire and Cable Co.

Circle No. 281

Reactance slide rule

The reactance slide rule is a helpful time-saving means for solving resonant frequency capacitive reactance, inductive reactance, coil Q and dissipation factor problems. For example, if inductance is set opposite capacitance in one window, resonant frequency is read out in another. Or, if resonant frequency is set in one window, L and C are read out in another. The rule covers a frequency range of 5 Hz to 10 GHz. Detailed instructions and a complete set of sample problems.

Available for $1 from Shure Bros., Inc., 222 Hartrey Ave., Evanston, Ill.



Fault current calculator

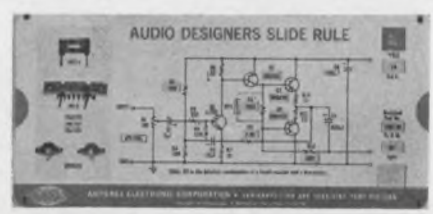
For any transformer rated from 150 to 2000 kVA, any copper wire size, voltage ratings from 208 to 600 V and distance from 0 to 200 feet, this slide chart calculates the fault current. Once the fault current is determined, a protective device with adequate interrupting rating can be selected immediately. In addition, this calculator lists characteristics of molded-case circuit breakers and fuses as well as dry-type transformer data. Federal Pacific Electric Co.

Circle No. 282

Pitch diameter table

A handy 22 x 28-in. wall-type thread chart contains tables of pitch diameters and gage limits, helix angles, best-size thread wires, and constants and tolerances for plug gages. Size Control Co.

Circle No. 283



Audio design slide rule

By selecting wattage desired in one window of this audio slide rule, the amplifier circuit rated at that wattage appears complete with component values and 2N numbers. In, addition, other windows give the complementary pair for the output stage and the speaker impedance. The reverse side of the rule determines V_{cc}, I_c, V rms and I rms for known wattages or load resistances. A set of complementary symmetry formulas is included.

Available for $0.50 from Amperex Electronic Corp., 230 Duffy St., Hicksville, N. Y.

IRC

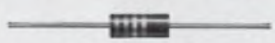
Fixed composition resistors offer

Greater moisture resistance

When tested to MIL-R-11 moisture resistance requirements, IRC's ½ and 1 watt fixed composition resistors exhibit resistance changes of less than 3%. Five times better than the 15% MIL allowance. Under more stringent conditions of 75°C, 100% RH for 120 hours, resistance changes are typically less than 5%. Even IRC's small ¼ watt unit has moisture resistance changes well within MIL limits.

Molding makes the difference. IRC's resistance element is a carbon composition film that is thermally bonded to a glass body. This exclusive IRC design permits up to 50% more molded protection completely around the resistance element.

The molding material was developed by IRC specifically for superior moisture, electrical, and mechanical characteristics. This exclusive molding material, plus added insulation thickness, brings an extra measure of moisture protection to your circuit design. Write for catalog, prices and samples to: IRC, Inc., 401 North Broad Street, Philadelphia, Pa. 19108.



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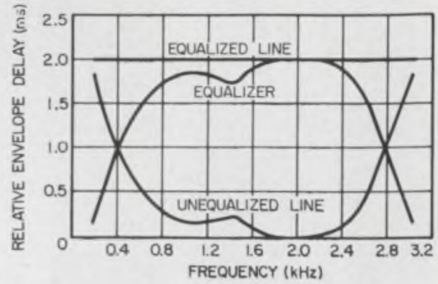
Application Notes



Delay equalization

This 8-page engineering bulletin explains the equalization of telephone lines to make them suitable for high-speed data communications. The illustrated brochure discusses the basic problem of delay distortion, talks about delay equalizers and considers various methods of employing equalization devices. Delay characteristics are plotted for 0.6-, 1.6- and 2.8-kHz all-pass networks. Rixon Electronics, Inc.

Circle No. 284

Log amplifier testing

Some common pitfalls in testing logarithmic amplifiers can be avoided with the help of this tecnhical note. Unusual test results with log amplifiers result from the logarithmic nature of their output. On a linear to log output scale, high output values are represented by compressed voltage levels, while smaller outputs have a relatively larger portion of the possible output devoted to them. Difficulties which arise in testing as a result of this logarithmic output, together with both a theoretical and practical interpretation of these test results, are discussed. RHG Electronics Laboratory Inc.

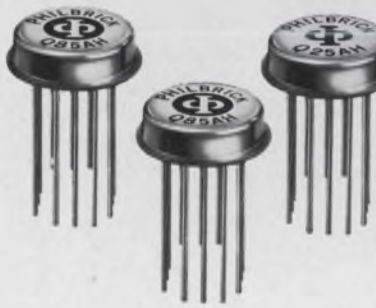
Circle No. 285

Hybrid circuitry

Featured in this 4-page brochure are a series of five photographs illustrating the step-by-step assembly of a typical hybrid circuit, from the polished ceramic substrate to the completed circuit assembly. Diagrams of a power supply regulation circuit, an analog gate using FETs and a high-performance amplifier with a voltage gain of 100,000 are also included. Amelco Semiconductor.

Circle No. 286

Philbrick's NEW BREED Micro-Hybrid Operational Amplifiers Obsolete Monolithics

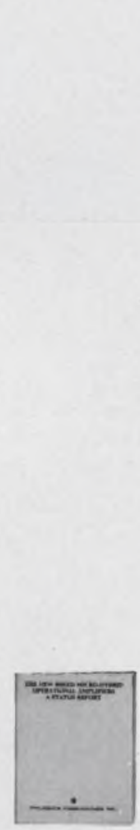


If you are still using monolithic-chip operational amplifiers, your system may be on its way to obsolescence — perhaps even before it gets off the board. A full year of industry-wide evaluation has proved it.

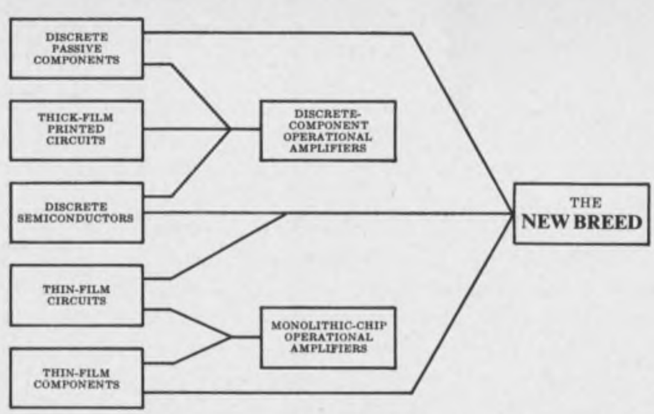
Philbrick's NEW BREED of "micro-hybrid" operational amplifiers combines the best of the linear-monolithic and discrete-component technologies. The result: a line of "micro-hybrid" operational amplifiers unequalled in reliability and performance. You'd expect premium amplifiers like these to cost more. They do — but your total system cost, *including design, development, materials, and production*, is usually substantially *lower* when you use NEW BREED Operational Amplifiers.

You can bid, win, and build highly superior "third-generation" systems with the NEW BREED — systems with an order of magnitude better performance, and absolute immunity to overloads, shorts, and supply-voltage stresses. *Without* the NEW BREED, your analog Aerospace/Weaponry designs are no longer competitive — technologically *or* economically.

More than 200 systems organizations have evaluated (and many have already approved) the NEW BREED. The facts are all assembled in our report entitled "*THE NEW BREED MICRO-HYBRID — A STATUS REPORT.*" Write, wire, or phone for your copy. Philbrick Researches, Inc., 46-0 Allied Drive at Route 128, Dedham, Massachusetts 02026. TWX (617) 326-5754. Telephone (617) 329-1600.



GENETIC EVOLUTION OF THE NEW BREED HYBRID



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ON READER-SERVICE CARD CIRCLE 105

New Literature

Dc power supplies

Applications of regulated dc power supplies are described with ratings and parameters in this 82-page catalog. In addition to presenting specs on rack and bench supplies, the catalog contains a 32-page application section covering power supply circuit principles, operational features and options, special application problems, specifications, definitions and measurements. Hewlett-Packard/Harrison Div.

Circle No. 287

Testing solder assemblies

A simple test for use after soldering, to determine the presence of chloride ions in rinse water or on cleaned electronic hardware is described fully in this technical report. The publication includes complete instructions for carrying out the test using an aqueous silver nitrate solution. Alpha Metals Inc.

Circle No. 288

Vibrator replacement guide

An 8-page vibrator replacement guide for communications and CB equipment is offered. Section one is a cross-index of communications manufacturer's vibrator numbers and replacement vibrators. Section two is a communications replacement guide by alphabetical listing of manufacturer's trade name showing replacements for each. Section three deals with replacements for CB manufacturer's vibrators. Cornell-Dubilier Electronics.

Circle No. 289

Servo components guide

A 6-page, 2-color dc direct-drive servo components condensed selection guide describes a line of torque motors, tach generators, tach torquers and duplex torquers. The guide describes basic operating principles and outlines advantages. Also included are complete electrical and mechanical characteristics on a group of representative models from each product line and basic formulas and data that offer selection guidelines. Inland Motor Corp. *Circle No. 290*

Potentiometer catalog

Wirewound single- and multi-turn precision pots and turns-counting dials are covered in this 4-page brochure. The catalog contains complete electrical, mechanical and environmental specs and prices. Duncan Electronics, Inc.

Circle No. 296

Differential amplifiers

This 12-page applications bulletin covering differential amplification includes a section on basic theory together with diagrams, formulas and applications. Other sections provide discussions of design requirements and performance characteristics and limits of differential circuits. Zeltex Inc. *Circle No. 297*

Copper wire soldering

The technology of soldering the fine copper wire in microcircuit devices and low-power circuitry is covered in a 4-page bulletin. It summarizes methods for overcoming the difficulties of soldering this type of wire through control of alloy composition, soldering temperature, type of flux, and use of appropriate soldering procedures. The publication discusses the metallurgical aspects involved in soldering magnet wire, and describes dip, wave and hand soldering. Areas of potential trouble are outlined, and suggested solutions are enumerated. Alpha Metals Inc.

Circle No. 298

Micromin glass semis

An unusual booklet, "Story of the Little Giant," describes the evolution of IC-compatible micro glass components. The 20-page "Little Giant" covers the microminiature glass-encapsulated zener regulator in a picture/copy fashion. Hoffman Electronics Corp.

Circle No. 299

Film firing kilns

Conveyorized furnaces used for film firing of capacitors, resistors, terminals and integrated circuitry are covered in this brochure. Inside and outside dimensions, zones, ratings and voltages, temperature ranges, and a complete description of the process are given. Firing requirements of resistor and capacitor compositions are included. Trent, Inc.

Circle No. 300

Switch catalog

A full line of rotary, pushbutton, lever and slide switches is described in this 8-page catalog. Complete specifications, from finishes to insulation materials, for each type of switch are listed. Also included is a special section on switch hardware which enables design engineers to assemble their own switches for prototype work. Oak Mfg. Co., Div. of Oak Electro/Netics Corp.

Circle No. 301

Trimming capacitor catalog

Standard precision, non-rotating piston trimmer capacitors are covered in this 16-page catalog. The brochure includes over 300 types in PC, vertical and panel mount styles with easy reference charts. Voltronics Corp.

Circle No. 302

Binary ladder networks

Information on current-summing networks is given in this 10-page bulletin. In addition to a discussion of test methods for ladder networks, formulas for determining proper resistor values to establish various attenuation factors are included. Angstrohm Precision Inc.

Circle No. 303

From .5 to 10,000 *pf*, the CYFM is the second best capacitor you can buy.

*p*f for *p*f, you can't buy more stability and reliability per dollar than you get in the CORNING® CYFM Capacitor.

You get the kind of stability that only a glass dielectric can hold, that's invariable with time, temperature, and environment.

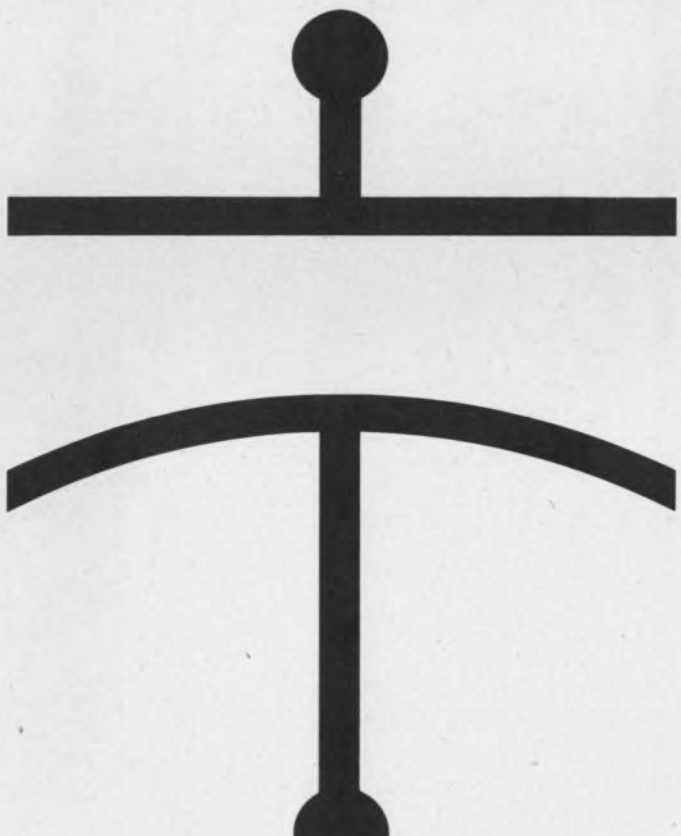
You get reliability that's inherent in the way they're made, which is basically the same process that turns out our ultra-high-reliability CYFR Capacitor.

But you save dollars on the CYFM because we don't put it through all the rigorous CYFR testing.

A CORNING CYFM Capacitor is practically indestructible under severe environmental stresses. We have boiled them in salt water, immersed them in saturated steam, subjected them to 96 hours of salt spray, without a failure or degradation.

After 2000 hours at 125°C with 150% of full rated voltage, capacitance change on a CYFM is less than 0.5%.

Why ever risk an entire system on capacitors that can't give you the assurance of Corning dielectric stability? Get all the economical facts on the CYFM Capacitor in our new CORNING® Glass Capacitor Guide. Send to Corning Glass Works, 3909 Electronics Dr., Raleigh, N.C.



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NEW LITERATURE

Digital circuit modules

A 48-page technical catalog describes a line of low-noise digital circuit modules. The catalog includes physical characteristics, operating specs, related equipment, design aids and application notes for 28 encapsulated modules. Typical modules include most configurations of flip-flops, NAND/NOR gates, relay and indicator drivers, voltage comparators, power drivers and multicircuits. Engineered Electronics Co.

Circle No. 304

Carbon-film resistors

This 12-page brochure details a line of precision metal- and carbon-film resistors for severe applications. One section covers conformal and molded metal-film resistors. Hard-glass hermetic precision resistors, and carbon-film resistors are described in other sections. Cutaway diagrams, tables and graphs provide complete specs and typical characteristics of the resistors. Texas Instruments, Inc.

Circle No. 305

Capacitor reliability

A 26-page brochure describes a report on the reliability of tantalum-foil capacitors. The bulletin states GE's definition of reliability and why it is important to the capacitor industry. Product reliability is discussed in terms of features and capabilities. Graphs illustrate normal reliability tests and results. Test equipment photographs are included along with charts showing yearly quality control audits of tests, and life test and failure rate status reports. General Electric Co.

Circle No. 306

Computer books

Current books of interest to computer programers and designers are described in this 4-page bulletin. The 21 books cover numerical analysis and computing methods, business data processing, digital computing, mathematical machine theory, sequential machines, linear data smoothing, switching systems, approximation of functions and language and information. Addison-Wesley Publishing Co., Inc.

Circle No. 307

Power supply modules

A 4-page, short form catalog includes listing of low-voltage midget modules, a new series of subminiature modules for mounting on PC boards, two new series of medium current transistorized power supplies and an expanded list of unregulated power supplies. Data is also included on the characteristics of dual output modules for application with op-amps. Ferrotran Electronics Co., Inc.

Circle No. 121

Timing handbook

The "Design Engineer's Timing Handbook," a 12-page manual, covers a wide range of electronic timing devices, both military and industrial. Complete electronic and mechanical specs are featured with a glossary of terminology and environmental characteristics. Artisan Electronics Corp.

Circle No. 122

Testing magnetic tape

A new certification process which locates all defects in digital computer tape is described in this 12-page folder. A special center fold has pull-out sections comparing the area tested by the new process to those checked by usual procedures. U.S. Magnetic Tape Co.

Circle No. 123

Potentiometer wire

Low-resistivity gold alloy wires are described in "Data on LR Potentiometer Wire." Included are tables indicating resistivity, tensile strength, temperature coefficient of resistance, precious metal content and diameter/resistance values of the wires. A typical scope pattern shows the typical noise level of potentiometers wound with these alloys. Sigmund Cohn Corp.

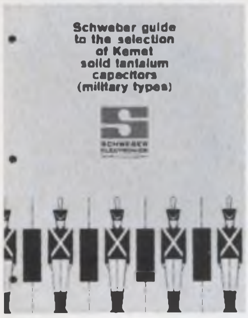
Circle No. 124

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card.

(Advertisement)

Kemet Solid Tantalum Capacitor Guide



The Schweber Guide to the selection of Kemet solid capacitors (military types) is a 4 page compilation of solid tantalum capacitors from .0047 MFD thru 330 MFD in voltages from 6 to 100 Vdc. The layout is unique because the capacitors are listed in numerical sequence by microfarads, thus enabling the engineer and buyer to quickly and easily select the proper capacitor needed. Also listed is MIL-C-26655B chart showing meaningful breakdown of each part number.

Schweber Electronics
Westbury, N. Y. 11591
(516) ED 4-7474

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Power Conversion Equipment

This new technical catalog describes equipment you may use to simplify your system design, test installation or laboratory setup. Data included on megawatt power sources for industrial applications as well as uniquely packaged regulated supplies for aerospace. Emphasis on general purpose dc power supplies, high power converters, variable frequency inverters, ac-dc converters. Free to qualified engineers.

Cal-Power Corporation
140 Kansas Street
El Segundo, California

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Books For The Electronics Engineer

The 1966 Hayden Book Company, Inc., catalog contains such new titles as "Microelectronic Design," "100 Ideas for Design '66," "The Electron in Electronics," "Synthesis of RC Networks with Arbitrary Zeros," "Transistor and Diode Network Calculations," and "Matrix Algebra for Electronic Engineers." As well as the expanded list for design engineers, the catalog includes Hayden and John F. Rider Publisher training texts at all levels. Send for your free catalog today.

Hayden Book Company, Inc.
116 West 14th Street
New York, N. Y. 10011

173

NEW LITERATURE

Iron-base resistance alloy

Complete physical, mechanical and electrical data on the properties of Fe-Cr-Al-Co resistance heating alloys is contained in this brochure. The brochure describes four different alloys. Kanthal Corp.

Circle No. 308

Op-amp catalog

Full specifications and performance data on the manufacturer's op-amps are given in this 8-page catalog. Also included are specs on boosters, power supplies and accessories. A special page includes diagrams of case styles and connectors. Zeltex Inc.

Circle No. 309

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—Reports Thomas E. Barth, Field Sales Manager & Advertising Manager, Kurz-Kasch, Inc.

Kurz-Kasch, Inc. has developed a system of qualifying inquiries received from their advertising and promotion program. As a result, they are able to rate "the qualifications" or quality of readership of publications. Field Sales and Advertising Manager, Thomas E. Barth writes:

"Interestingly enough, of the inquiries received from our April 12 ad in Electronic Design, we enjoyed a 50% higher response rate in qualified - returned questionnaires than from any of the other publications we have used.

"What better test of a publication's value can be made?"

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Designer's Datebook

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6	7	8	9	10	11	12
13	14	15	16	17	18	19
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27	28	29	30			

DECEMBER

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Nov. 2-4

1966 Northeast Electronics Research and Engineering Meeting (NEREM) (Boston, Mass.) Sponsor: IEEE, New England sections; T. A. Longo, IEEE Boston Office, 31 Channing St., Newton, Mass.

Nov. 8-10

1966 Fall Joint Computer Conference (San Francisco, Calif.) Sponsor: American Federation of Information Processing Societies; W. Estler, 965 Lincoln Ave., Palo Alto, Calif.

Nov. 14-17

19th Annual Conference on Engineering in Medicine and Biology (San Francisco, Calif.) Sponsor: IEEE and ISA; T. Weber, Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif.

Nov. 15-17

Fifth Annual Symposium on the Physics of Failure in Electronics (Columbus, Ohio) Sponsor: USAF & Battelle Memorial Inst.; T.S. Shilliday, Battelle Memorial Inst., 505 King Ave., Columbus, Ohio.

Nov. 15-18

Twelfth Annual Conference, Magnetism and Magnetic Materials (Washington, D. C.) Sponsor: IEEE and the American Inst. of Physics; V. J. Folen, Code 6452 U.S. Naval Research Lab., Washington, D. C.

Nov. 16-18

1966 Eastern Analytical Symposium (New York City) Sponsor: American Chemical Society, American Microchemical Society and Society for Applied Spectroscopy; Ivor L. Simmons, M&T Chemicals Inc., P.O. Box 471, Rahway, N. J.

Nov. 29-Dec. 2

AIAA Third Annual Meeting and Technical Display (Boston, Mass.) Sponsor: AIAA; Vincent J. Coates, Jr., Avco Everett Research Lab., 2385 Revere Beach Pkwy., Everett, Mass.

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TYPE	APPLICATION	APPLICABLE MIL SPEC AND TYPES	WATTAGE RATING	RESISTANCE RANGE	CORE SIZES	TOLERANCE
CW Axial Lead 	Axial leads. For applications requiring high performance at low cost	MIL-R-26 RW-57, 58, 59	4.25-13 watts	.1 ohm to 273K ohms	Body Dia. .188 to .375" Body Length .500 to 1.781" Leads 1.5 to 2"	±5%
HL Tubular 	Silicone-coated general purpose wirewound resistor. A direct replacement in both cost and performance for vitreous enamel types.	MIL-R-26C RW-29, 30, 31, 32, 33, 35, 36, 37, 38, 47	5-225 watts	.1 ohm to 1.3 Megohms	O.D. ¼ to 1⅛" Length 1-10½"	±5% (10% below 1 ohm)
NHL Non-Inductive 	High frequency circuits and applications requiring low inductive effect and minimum distributed capacity	None	5-225 watts	1 ohm to 90K ohms	O.D. ¼ to 1⅛" Length 1-10½"	±5%
HL Flat 	High power-to-size ratio. Self-stacking hardware for vertical or horizontal mounting.	MIL-R-26C RW-20 thru RW-24	24-95 watts	.1 ohm to 150K ohms	Length 1¼ to 6"	±5% (10% below 1 ohm)
HLM Miniature Flat 	For limited space, high power-to-size requirements particularly in high vibration areas.	None	10-20 watts	.1 ohm to 51K ohms	Length ¾ to 2-1/16"	±5% (10% below 1 ohm)
HLA Adjustable 	For resistance or voltage adjustment	MIL-R-19365C RX-29, 32, 33, 35, 36, 37, 38, 47	12-225 watts	1 ohm to 100K ohms	O.D. 5/16 to 1⅛" Length 1½ to 10½"	±5% (10% below 1 ohm)
HLT Tapped 	For voltage divider networks	None	11-225 watts	.1 ohm to 1.1 Megohms	O.D. 5/16 to 1⅛" Length 1½ to 10½"	±10% each section (±10% total)
HLW Tubular 	General application where terminal wires are required for direct electrical connection	None	5-20 watts	.1 ohm to 80K ohms	O.D. ¼ to 7/16" Length 1 to 2"	±5% (10% below 1 ohm)

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